Electrochemical and Metallurgical Industry

NEW YORK, MARCH, 1905.

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Power From Blast Furnace Gases.

In this issue we publish an admirable article from the pen of Mr. F. duP. Thomson who speaks authoritatively on this subject on account of his connection with the installation of the pioneer blast furnace gas power plant of this country. The subject is specially interesting in its relation to the problem of the use of the electric furnace in the steel industry. Aside from special cases with particular local conditions, it seems at present that the proper place of the electric furnace in the iron and steel industries is as an adjunct to, not as a competitor with, the blast furnace. The enormous amount of power which may be rendered available from blast furnace gases will be seen from the following estimate. The output of pig iron in this country in 1904 was over 16,500,000 long tons; on the basis of Mr. Thomson's quite conservative figure—468 hp. per ton of iron made per hour—this represents the possibility of developing nearly 900,000 hp. above all the requirements of the blast furnaces themselves. The significance of this figure is evident in view of the fact that, according to the last census report (1902), the total power in all electric central stations in the United States was 1,800,000 hp.

Metallurgical Calculations.

We are glad to announce that, beginning with the present issue, we will publish in our columns a serial on metallurgical calculations from the pen of Prof. J. W. Richards, whose enthusiasm in progressive metallurgy is coupled with a happy faculty of elucidating intricate problems, gained through his many years' experience in metallurgical teaching and consulting work. The scope of the serial is given in the introduction of the first article, and a comprehensive scope it is. We trust that this serial will gain many friends and may do much good; for the future of metallurgy depends chiefly on the sound amalgamation of practical metallurgical experience with the fundamental principles of chemistry and physics, which must underlie all metallurgical thinking. The time is over when the "rule of thumb" rules. The future belongs to the man who plans accurately what he is going to do and who controls what he is doing by checking the figures obtained in his work with the figures calculated in advance, to see how far he is successful in accomplishing what he is after. Metallurgical calculations were formerly mistrusted by practical men, and criticisms of this kind were occasionally backed up by references to cases in which a certain formula taken from a certain pocket-book and applied in practice did not give correct results. The fault, however, was less with the formula than with the man who tried to apply it at random. It is a most dangerous thing to apply any formula whatever without completely understanding its derivation and all the suppositions on which it is based. Formulæ are nothing but a kind of short-hand writing; there can be no value in a formula if it is not based

on sound reasoning, and the best formula is of no value in a special case if the conditions in this case are different from those assumed in the derivation of the formula.

What a metallurgist should aim to acquire is not a collection of formulæ—a treasure of doubtful value—but rather a faculty of making calculations for himself. This requires above all sound common sense, which cannot be taught; but it also requires a knowledge of facts and principles. There are, indeed, a certain number of fundamental principles of reasoning which will fit a great many apparently different cases, and which come up again and again in metallurgical calculations, like a Leitmotiv in an opera of Wagner. These leading principles of calculation can be taught and learned, and we trust that Prof. Richards' serial will contribute to their dissemination throughout the metallurgical world. When a metallurgist is no longer ashamed nor afraid nor unable to check his work by calculations, then and then only is he enabled to determine exactly the weak points of his process and the chances of improvement. And even in such cases where a sound metallurgical calculation yields results which are not confirmed by practice, there is no reason to sneer at the theory. Gayley's famous dry-blast experiment is a case in point; he obtained a saving of fuel several times greater than was to be expected from calculation. But this result simply shows that we did not yet know everything which was really worth knowing concerning the phenomena in the blast furnace—that the explanation of this disagreement must lead to a better understanding of the blast furnace. We can promise our readers that Prof. Richards' articles will not be all easy reading, they will at times require study; but we think we can also promise that whoever masters them will gain much and varied practical information of metallurgical principles.

Continuous Versus Intermittent Process.

In our last issue, we made editorial reference to the far-reaching and fundamental question of the metallurgical difference between a continuous process and an intermittent process. There are to be found in America's industrial development numerous good examples of each type. We mention among the continuous processes that of the lead, copper and iron blast furnaces, of the cement kiln, the mechanical ore roasters, crushing machinery, ore-dressing machinery and gas producers. In the intermittent processes, are found the desilverizing base lead bullion, bessemerizing pig iron, or refining pig iron to steel in the open-hearth furnace, bessemerizing high-grade copper matte to "blister" copper, or doing the same operation in the reverberatory furnace (all four of the last instances showing a curious parallel between copper and steel metallurgical practice), etc. In this classification it is seen that, as a general rule, for doing the rough work on the ore with the formation of a crude concentrated product and of a waste product containing little metallic value, the continuous furnace has won in the great metals, iron, lead and copper, undisputed sway, while for the finishing or the refining treatment the intermittent process is commonly used.

For such a generalization as this there must be some reason. It was a dictum of the late Herbert Spencer that nothing in this world of chance results in an orderly arrangement without a cause for this order. The cause for order in this case is that in a continuous process the conditions are held nearly rigid while the material in the process flows, while in an intermittent process the material is fixed, while the conditions can be varied to suit the needs of the treatment. In the first case, the quality of the product is a matter of some indifference, the goal to be attained is a large tonnage handled at a low cost. In making lead bullion, the small amounts of such impurities as copper, arsenic, antimony, etc., will vary greatly from day to day without serious effect on the cost-sheet of the lead smelter. The real problem is to increase average monthly tonnage of plant by keeping furnaces open and running at full capacity, and to make a large proportion always low in silicon and lead, so that only small percentage needs be retreated. The first treatments are really concentration of values. On the other hand, in the refining process quality is of all importance. To control quality of product, the operator must be able to vary conditions at will. No refinery can sell metal of a purity of 99.9 per cent one week, and the next week of 99.0 per cent. As the refining process requires such to be the state of affairs, the intermittent process fits the category nicely and exactly. A central furnace reservoir, like the "mixer" of the modern steel plant, will average the impurities, but the open-hearth furnaceman, by his control of flame and fluxes, can eliminate them to the extent demanded by the use of the finished steel. By putting a chemical laboratory near the furnace when steel of desired quality is produced, the treatment is stopped and the furnace tapped.

To expand this idea, we see that the cost of labor per ton of output on a continuous furnace is low, for if the conditions be held constant and the charging of the furnace be constant also, mechanical means can be devised to do the work. The units are made of tremendous size, for everything is known. There is no time lost in charging the furnace, and thus capital invested in it is not idle for a part of the time. The continuous furnace is not subjected to strains in cooling during charging, and thus its life is longer. "Continuous processes make continuous profits." Two curious half-exceptions are found to this generalization. These are zinc and aluminium. The reduction of zinc is done in an intermittent final process. The refining has been done largely in the ore-dressing, which is a continuous and concentrating process. In the metallurgy of aluminium, the refining is really done in the first chemical process extracting by caustic soda the pure aluminium oxide from the crude bauxite. The final reduction is done by the Hall continuous electrolytic process. Both these exceptions have common properties: great difficulty of reduction and their volatility at temperatures of reduction. One requires heated carbon in a closed retort; the other requires less heat, carbon, and that great reducer—the electrolytic potential of the direct current. So both these "half-way" exceptions show a logical similarity in their partial dissimilarity. In industrial electrochemistry, it is seen that high temperature furnaces, e. g., graphite and carborundum furnaces, are intermittent because their extremely high temperatures apparently make a permanent continuous furnace nearly an impossibility. The carbide furnaces are semi-continuous in operation. Electrolytic copper refining possesses peculiar characteristics, but it can be put in the intermittent class. The Castner-Kellner

caustic soda cell is beautifully continuous. In the electrometallurgy of steel, the electric furnace is of the refining intermittent type—which is just its proper place. The great example of intermittent treatment applied to ores is the leaching of ores by solvents, such as cyaniding gold ores. Here, we find a strong desire for a continuous leaching plant and filter press. Such a plant would be cheaper in construction and operation. Another point to be noted is that most primitive processes and most processes in the experimental stage are intermittent. This is but natural, for when the right conditions of the reaction are yet unknown, it is impossible to do the hard task of working under rigid conditions. Thus it is with the old Chinese processes of making iron by heaping up coal about a crucible containing iron ore, piling clay about it and tearing down the crude furnace at the end of the operation. This is quite analogous to our present high temperature electric furnace. As Americans have only been making carborundum at some 3000° C. for ten years, while the Chinese have been making iron at some 1400° C. for a few thousand years, we may not be ashamed to be compared to the Chinese in this respect. The perfectly natural law for the classification of metallurgical reactions shows that the same underlying philosophical principles pervade applied science, as well as all human relations. They are always in the mind of the industrial pioneer, sometimes consciously, but often unconsciously; for, in general, intuition, not analysis, guides the inventor.

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Trusts and Metallurgical Advance.

Evolution is defined as a process of change from a state of homogeneity to a state of heterogeneity through a series of differentiations and subsequent integrations. By such a process has nature evolved out the primordial "world-stuff"—the simple electron—the large complex molecule of albumen which contains several million electrons. By such a process man has come to his present physical and spiritual being from the first little proto-plasmic bit. And every organism is now growing from the simple to the complex. As long as man has been ministering to his needs the changes in his methods of ministering have been along these same lines of organic growth. Not so long ago each man was his own "butcher, baker and candle-stick maker," but the growth of society has caused a rapid classification of industry. This progress has reached its apogee in a corporation employing over one hundred thousand men, owning its own mines, steamships, railroads, iron and steel works, and plants for turning the steel into many finished products. Such a corporation is a wonderful and complex organism, even more wonderful and complex than the albumen molecule. Thus the large corporations commonly called "trusts" are the legitimate outgrowth of economic evolution. Under present conditions they cannot be repressed by hostile legislation. The intelligently and honestly directed trust is omnipotent. Possession of large working capital, large-scale production, ownership of large sources of raw material, control of the market from unnecessary fluctuations are a few of its advantages. Strong financial connections, distributing orders to its plants according to favorable geographical locations, employing labor regularly 300 days a year (the only efficient way), pooling metallurgical experiences of all plants, all these present a striking array of secondary points of indus-

trial superiority. Concerning the last point—the pooling of experience due to consolidation of companies—the following true story is instructive: A company absorbed recently two rather widely separated street railway systems. The superintendent of the one system was instructed to report on the operation of the other road, and suggested a number of improvements which had escaped the attention of the resident manager. The result was such a decisive reduction of the cost of operation that the manager of the second road was instructed to report on the first road. He recommended economies of an entirely different kind, but which were equally effective in lowering the operating cost.

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Like every giant, however, the trust has weakness. One weak point will be like Goliath's, in the head. The present able managers and engineers were developed by strongest and keenest competition. They are men who operated plants under adverse conditions; men who installed new machinery; bold innovators and pioneers; men full of resource, patience and courage. Their endeavors built the great metallurgical plants of the country. Thus comes up the question, how will the successors of these men be trained? The policy pursued as to training young men, of seeming unimportance now, can make or unmake the corporation in the future. If the managers and engineers of the future are not trained in the spirit of our age, and are not of the highest type, "dry rot" will spread and the trust will be, 100 years from now, an extinct species, like the other large animals, such as the Brontosaurus in the New York Museum of Natural History. Obviously, there must be new blood infused into the technical and business staff. How to do that logically and effectively is one great problem for the directors of a trust. Much of course is done by metallurgical competition between the different plants. This will effect the details of the process, so the things are not hopeless. But the great basic improvements will come in large part from outside competition. In many instances the metallurgical nestors turn down a new process from natural conservatism. A new process will, if successful, nullify the investment value of many millions of dollars; while, if turned down by the trust, it may fail for commercial reasons. This has often been the case. On the other hand, the independent can scrap the small old plant and build a new plant on radically new lines of quadruple capacity. This move has often been made, and is a good stroke of business. For the "largest interest" to do this would be impossible, for the increased capacity would exceed consumptive demand of the country. The trust could not do more than build to its present capacity. The smaller concern would have much better reasons and stronger incentives for taking chances on the first work of a new process. Were it not for the fact that the logical attitude of the belligerent independent is to stimulate metallurgical activity and that this will react favorably on the trust, the outlook for advance would be most gloomy. The large corporation without active competition has the best of reasons to rest on its oars. Any legitimate enterprise can obtain capital for industrial purposes. So we have reasonable hopes for believing that American independence of action will keep up the continuous march of progress in applied science.

Notes.

American Electrochemical Society.—In the February meeting of the Board of Directors, Mr. F. A. Kjellin, of Gysinge, Sweden, and Mr. Simon G. Engle, of Monticello, Ind., were elected members of the society. A preliminary announcement of the programme of the Boston meeting will be found further below.

Society of Chemical Industry.—The programme of the meeting of February 24, of the New York Section of the Society of Chemical Industry, comprises papers by C. Richardson and C. N. Forest on tetrachloride of carbon and its use as a solvent in the differentiation of bitumen; H. Schweitzer on the history of artificial musk; W. G. Berry on tannin.

Electrometallurgy of Iron and Steel.—At a recent meeting of the Canadian Society of Civil Engineers, Dr. E. Haanel, superintendent of mines, of Ottawa, Canada, read a paper on the electrothermic production of iron and steel. He summarized concisely the work and the conclusions of the Canadian Commission of which he was the head (abstracted at length in our December issue, 1904). The author predicted a very rapid development of electrical methods. He pointed out that the older metallurgical methods of steel-making had almost reached their limit of economic development, and no very startling reductions in cost are probable, whereas electrothermic methods, although new, have already been so successful as to justify the belief that they will soon become of great commercial importance.

Clays.—In circular No. 17, issued by the United States Department of Agriculture, Bureau of Chemistry, Dr. A. S. Cushman gives a very useful summary of our knowledge of clays. The contents of the pamphlet are as follows: Formation of clays, production and importation, kinds of clay, physical properties of clay (plasticity, binding power, slaking, air shrinkage; firing qualities, namely, fire shrinkage, fusibility, color; absorptiveness, purification and treatment of clays, use of clays, testing and examination of clays.

Worcester Polytechnic Institute.—We have received the thirty-fifth annual catalogue of the Worcester Polytechnic Institute for 1904-5. The total number of graduates of the Institute is now 1057, the number of members 2020, so that the percentage of graduates is 52.

Optical Pyrometry.—We recently referred to the most excellent summary by Dr. C. W. Waidner and G. K. Burgess of the present status of optical pyrometry (bulletin No. 2, Bureau of Standards). This paper has now been published as a pamphlet of the Department of Commerce and Labor, Bureau of Standards.

Electric Steel Furnace.—The Héroult process for making steel in the electric furnace was the subject of a recent paper of Mr. Charles Combes, presented before the Society for the Encouragement of National Industry in Paris.

The Technical School and the University.—A most interesting paper on this subject was recently presented by Prof. Henry M. Howe before the Association of American Universities in Baltimore: "Will technical schools serve the interests of the community better if they are parts of great universities, or if they are isolated institutions? Is association or isolation more to the public good?" * * * "The technical man is always occupied with questions of profit and cost, of making money for his employer, or of building as cheaply as his standard of quality will permit. The merit of every plan is measured in dollars, be it mining and smelting, manufacturing, transportation or agriculture. The subject must be taught from this standpoint. Our graduates must be sufficient money-makers; but it is still more important for the community that they should be liberal citizens." * * * "The technical teachers should have the softening and broadening influence of contact and work with teachers of the humanities and of pure science. * * * Conversely, it is for the good of the public that the teachers of pure science, and more particularly those of the humanities, should, in turn, be broadened by contact with the technical school."

Prof. Howe then spoke of the interaction of different classes of students. "The serious technical student unexpectedly learns from his fellow of the college, of the delights of this or that writer; of the existence of this or that school of philosophy; his interest in things beautiful is awakened; a chat with the student of architecture sets him thinking about the genesis and meaning of logical finished Doric and soaring spiritual Gothic. Each student from another department cries *'Audi alteram partem;* however good and healthy your interest may be, they are only one group out of many.' The technical student's horizon is broadened; and truly it needs broadening. According to my observation, narrowness is the chief defect of the isolated technical school. Like students of the other learned professions, the technical students, are as a class more earnest, more zealous, than their fellows of the college; they are more mature, and they see more clearly than the college student the bearing of their studies upon their life's work." However, there may be conditions where the matter is not so simple, for instance, if in creating a new technical school, the choice should lie between isolation and association, not with a university, but with some long-established college which has as yet no professional schools, and thus is itself isolated. Prof. Howe then discussed the economy resulting from association—in saving salaries and in widening the use of the more expensive instruments, as well as in fitting work to worker, and best of all, in more fully supplying the eminent with work on their own plan. Prof. Howe concludes that "wisely guided association, while it need neither deprive the technical school of character and individuality, nor injure any of those in interest, should benefit the community, whose welfare here deserves our chief thought."

American Electrochemical Society.

The annual meeting to be held in Boston, Mass., on April 25, 26, 27, promises to become a most memorable one in the history of the society. The local committee, with Prof. W. H. Walker as chairman, is making extensive arrangements.

The following preliminary list of papers has been announced:

A. B. Albro, "Microstructure of Silicon and its Alloys."

J. C. Blake, "The Migration and Coagulation of Colloidal Suspensions."

H. R. Carveth, "Chromium."

Ernst Fahrig, "Treating Low Grade Ore and Tailings by Electrolysis."

H. M. Goodwin, "On Billitzer's Method of Determining Absolute Potentials."

C. Hambuechen, "An Optical Method of Observing Diffusion in an Electrolyte."

Carl Hering, "Removing Solvents During Electrolysis."

G. A. Hulett, "A Low Voltage Standard Cell."

L. Kahlenberg, "Osmosis."

A. Lodyguine, "Some Experiments with the Reduction of Titaniferous Ores Into Steel and Titanate of Iron."

A. Lodyguine, "Experiments with the Reduction of Different Oxides of Lead by Electric Current."

A. Lodyguine, "Some Results of Experiments with the Electrodeposition of Metals on Aluminium."

A. Reuterdahl, "The Interdependence of Atomic Weights and Electrochemical Equivalents."

J. W. Richards, "Conduction in Electrolytes."

C. C. Richardson, "Water Powers of the Canadian 'Hinterland.'"

R. C. Snowden, "Electrodeposition of Silver."

R. C. Snowden, "Adherence of Nickel to Nickel."

C. P. Townsend, "A New Diaphragm Cell."

Other papers are expected from Messrs. W. D. Bancroft, C. F. Burgess, A. J. Rossi, and others.

We are also informed that access can be had in or near the convention hall to a plentiful supply of electric current for demonstrations and exhibition purposes, should any manufacturers of special electrical apparatus, electric furnaces, etc., desire to exhibit. While, on account of limitations of space, a general invitation cannot be extended to manufacturers and dealers to display their products, the committee will be glad to make all possible arrangements for such exhibits, should those interested apply to Prof. H. P. Talbot, secretary-treasurer of the committee, whose address is at the Massachusetts Institute of Technology.

The hotel headquarters will be at the Hotel Lenox, Boyleston and Exeter Streets, Boston.

The complete programme of the meeting will be published in our next issue.

Faraday Society Meeting.

The eleventh ordinary meeting of the Faraday Society was held on Monday, January 30, 1905, at the Institution of Electrical Engineers, in London, Prof. A. K. Huntington being in the chair.

MASS ANALYSIS OF MUNTZ'S METAL BY ELECTROLYSIS.

The first paper of the evening was presented by Mr. JOHN G. A. RHODIN, the subject being "Mass Analysis of Muntz's Metal by Electrolysis," and some notes on the electrolytic properties of this alloy.

The first portion of the paper describes an apparatus which was specially designed by the author for the purpose of the accurate and rapid determination of the copper content (which should lie between 60.5 and 61.5 per cent) of Muntz's metal. As about 40 to 60 "heats" of metal are cast every day, and it being necessary to obtain the results within twelve hours of the time of casting, the apparatus had to be such as to enable 100 analyses to be made in twenty-four hours—with a mean probable error of not more than $\pm$ 0.1 per cent. The author decided that an electrolytic method would best fit in with these stringent requirements.

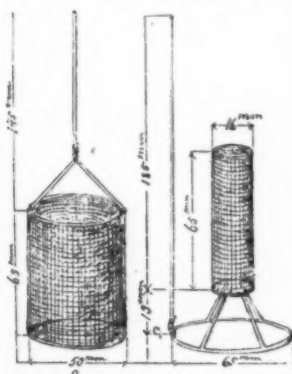The electrodes employed (Fig. 1) consist of concentric cylinders of very fine platinum gauze, supported by stout frameworks in order to ensure even current distribution. The anode rests on a ring at the bottom of the containing vessel, so that the cathode can easily be slipped away and removed, and both electrodes are held in modified Classen stands. The present installation consists of thirty such unit cells, and current is supplied to them from six pairs of accumulators, each of which supplies current to five pairs of electrodes, through suitable nickelin resistances.

Fig. 2 is a diagram of the connections of two sets of five pairs of electrodes. The batteries B_1 and B_2 are connected to the conductors L_1 and L_2, and L_3 and L_4, respectively. The conductors are enclosed in wood casing, screwed down to the table. Parallel branches run to the different electrodes, a_1 and c_1, a_2 and c_2, etc., but the main conductors L_1 and L_2, and L_3 and L_4, are insulated from each other between the sets, so as to prevent the batteries from discharging into each other. In each one of the secondary branches there is a re-

FIG. 1.—ELECTRODES.

sistance, R_1 or R_2, etc. These resistances can be shunted at S_1, S_2, S_3, etc. All the resistances are made from No. 20 nickelin wire, stretched on porcelain bobbins in front of the table. Hence, they can easily be got at, and this is convenient for repairs, which have frequently to be made when electrolytic work is carried on continuously.

One gram of the alloy, dissolved in nitric acid, is used for an analysis, and a current either of 0.5 amperes or else of 2.0 amperes is employed for the deposition. In the former case deposition is complete in twelve to fifteen hours, in the latter in three hours. Electrolysis proceeds in three phases: (1) Copper deposition and ammoniacal reduction of nitric acid. (2) Ammoniacal reduction only. (3) Deposition of zinc. A perfect separation takes place if phase (2) occupies a long time, and is unaccompanied by metal deposition. If certain impurities, such as arsenic or nickel, be present they must be removed chemically. The paper describes in detail the actual procedure at the works laboratory, and also includes a table showing the kind of accuracy obtained in cases where reanalyses have been made. Since these analyses in bulk have
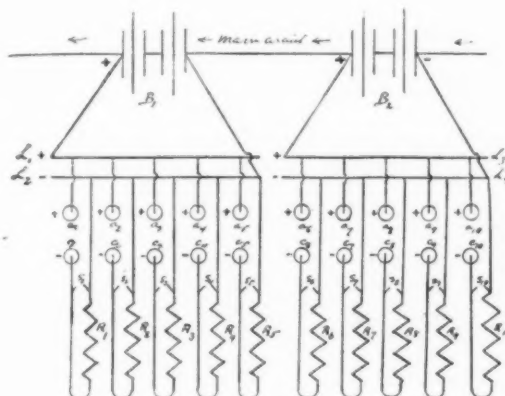
FIG. 2.—ELECTRICAL CONNECTIONS OF CELLS.

been made it has been found that they act as an infallible guide to the casters, so that remelting has now become very rarely necessary.

In conclusion, the author discusses the electrochemical properties of Muntz's metal. The metal is largely used as a sheathing to protect ships' bottoms from certain mollusca and algæ, and to be successful it should dissolve in seawater just to a sufficient extent as to render the surface poisonous, the best conditions being the equal dissolution of the copper and zinc. The author shows how these may be calculated approximately by supposing that the electrolytic dissolution rate is proportional to the heat of formation of the ultimate compounds (zinc and cuprous chlorides), and to the conductivities of the metals which dissolve. Assuming that both the chlorides of copper are formed, and taking the mean of the results in the two cases, the best values are found to be 60.811 per cent of copper, and 39.189 per cent of zinc, numbers which agree very closely with the results of practical experience. The author is now engaged in exhaustively investigating the *absolute* dissolution-velocity of pure Muntz's metal at a definite temperature, and he adds here a preliminary description of these experiments, describing in an appendix his most recent experiments on the subject. He finds that a binary alloy like Muntz's metal dissolves slowly at first, the velocity then quickly arrives at a maximum, then it falls suddenly—remaining almost constant for some time—and finally a more or less rapid fall again occurs. During the period of constant velocity the surface must alter as the resistance capacity, if the action is galvanic. The seat of e. m. f. must be in the electrolyte, as the constancy of action

indicates a steady e. m. f. of considerable magnitude. It is probable that the result is influenced by the actual mass of metal present, relative to that of the solvent. The external pressure certainly exercises a very considerable effect on the reaction-velocity, by influencing the speed with which hydrogen can leave the surface of the metal.

The author promised further communications on the subject.

EQUILIBRIUM BETWEEN SODIUM SULPHATE AND MAGNESIUM SULPHATE.

A paper on this subject was presented by Dr. R. BECKETT DENISON.

Experiments conducted from the standpoint of the phase rule are described, the object of which was to determine whether the double salt of sodium and magnesium sulphates, $2MgSO_4.Na_2SO_4$, which has been described as a naturally occurring mineral, is capable of existence in contact with solution; that is, whether it has been formed in nature by the evaporation of saline waters. The corresponding potassium compound is known to occur in Stassfurt as langbeinit, and it was thought that a detailed investigation might result in the isolation of the sodium langbeinit from solution.

A transition temperature of 59° C. was obtained for the system $MgSO_4.7H_2O + MgSO_4.Na_2SO_4.4H_2O$, but it was found that only the double salt loeweit, $Na_4Mg_2(SO_4)_5 5H_2O$, was formed, the usual transition-point (71°) being depressed to 59° C. by saturation with $MgSO_4$.

Dilatometer and tensimeter experiments pointed pretty conclusively to the assumption that the compound sodium langbeinit cannot exist in contact with solution, at least below 100° C., and hence, this substance, if found as a mineral, must be a product of a higher temperature.

Mr. E. KILBURN SCOTT gave a short abstract of his paper on "Refractory Materials for Furnace Linings," which dealt principally with carborundum, siloxicon, and electrically-shrunk magnesite. (Concerning the latter, see our Vol. II, page 454 and 455.)

At the next meeting, to be held on March 6, Mr. F. W. HARBORD (the metallurgist of the Canadian Commission) will read a paper on "Electric Steel Smelting."

Society of Chemical Industry.

The American Committee of arrangements for the next annual meeting of the Society of Chemical Industry, to be held during the second week of July, 1905, at London, consists of Messrs. Russell W. Moore, Chairman; T. J. Parker, Secretary; Virgil Coblentz, E. G. Love, H. Schweitzer and R. C. Woodcock. The committee has issued the preliminary programme and expresses the hope that as many American members as possible will attend and be present when the President, Dr. William H. Nichols, of the General Chemical Co., of this country, delivers his annual address.

The following programme has been provisionally arranged: During the first week in London, the annual meeting will be held, and the address of the President, Dr. William H. Nichols, will be delivered. Various excursions and visits in and around London are to be arranged.

During the second week visits will be made to places of industrial and historical interest in England, the guests being in charge of the provincial committee. Three separate excursions are contemplated, the first to places of historical interest (cathedrals, chiefly on the East Coast of England; Ely Lincoln Repose, Fountains Abbey, York, Durham); the second to the factories of the textile industries of Bradford, Birmingham, Nottingham, Burton-on-Trent, etc.; the third to chemical works, dye and print works, cotton mills and potteries in the vicinity of Liverpool and Manchester.

These visits will be so timed that the whole party will finally meet in Glasgow, where the Scottish Section will take care of the visitors and where the meeting will terminate.

The London committee has extended a most cordial invitation to ladies, and a ladies' committee has been formed, including those ladies who were present at the annual meeting in New York.

Electrolytic Separation of Metals.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In comparing the metallurgy of different metals, there are always found certain types of reactions that resemble each other. It is often quite possible to formulate a general principle that will describe the class to which these similar reactions belong. The way is first to recognize the similarity by intuition, and then by analysis to separate the essential points. Synthesize these and you have a general law.

In this connection two general principles are seen applying to the separation of metals by their selective electrolytic properties.

One general principle applying to the separation of a negative metal from a more positive one is by "acid electrolysis." For instance, to separate iron from copper in solution it is only necessary to have the concentration of the hydrogen as "ionic hydrogen" strong enough so that no iron can be deposited at the cathode under ordinary current densities.

In other words, the presence of 2 or 3 per cent of mineral acid will keep the "electrode potential" so low that only copper and a small amount of hydrogen is deposited. This is done in the case of iron and copper and nickel and copper in the electrolytic copper plant. The presence of the hydrogen ions keeps the iron or nickel in solution for the above reasons. The hydrogen ions act like a safety valve on a boiler, and prevent the cathode potential rising above the low limit, provided that the circulation of the catholyte is vigorous enough to neutralize the concentration changes set up by the electrolysis. This has been tried with many pairs of metals in analytical electro-analysis and in practical electrometallurgy.

A second general principle governing the electrolytic separation of metals is that of selective electrolytic dissolution of a composite metal anode. This is not always complete and can be followed by a cementation process in an outside vat.

For instance, if the anode consists of 90 per cent $M+$, and 10 per cent $M-$ at low rates of dissolution the cathode will be quite pure. However, if the current density be increased, the less positive metal will be dissolved and precipitated on the cathode in considerable amounts. But if the electrolyte be subjected to such a system of circulation that before much of $M--$ reaches the cathode, it is removed to another system, it is possible to remove $M-$ from the process by the reaction: $M+ + M- x = M+ x + M-$. Thus the electrolyte is kept in a continued state of purity.

It is, of course, necessary to have all the conditions right for the rapid and complete metallic precipitation above indicated. This is a question of "physical metallurgy," if a new phrase can be coined on the analogy of the phrase "physical chemistry." Such a reaction effectually stops any deposition of $M-$ at the cathode.

This set of reactions has been made use of in several processes. It has been the practice to run the copper electrolyte over shot copper. A German electrolytic zinc-silver process (C. F. Schnabel, *Handbook of Metallurgy*, Vol. II, chapter on electrical processes) is another example. I found it quite useful in some work I did a few years ago in the electrolytic refining of iron.[*] It is of general application and can be of value to many other separations of metals by electrical methods. WOOLSEY McA. JOHNSON.

New York City.

[*] U. S. Patent No. 780,191, Jan. 17, 1905.

Commercial Possibilities of Blast Furnace Gas for the Development of Electric Power.

By F. duP. Thomson.

Not until the Lackawanna Steel Company decided upon the use of gas engines for the development of electric power and for the compression of the blast with gas obtained from the blast furnace itself, did any iron manufacturer in this country take the initiative and install even a trial engine constructed for this special class of service. To those European iron masters who have demonstrated the feasibility of the system we are indebted for a long step forward in blast furnace economy, a step which has made possible the development of fully one million horse-power over and above the requirements of the blast furnaces themselves, when the output of this country is taken as twenty million tons of iron per year. Despite discouraging reports as to the results of European installations, made by American investigators, the blast furnace gas engine industry continues to grow.

When the first installation was made at Buffalo great activity prevailed in the iron trade. During the years 1899 to 1903 the volume of business was so great and prices so remunerative as to give no good reason to consider the expense of replacing equipment which answered the purpose, for money employed as working capital yielded greater returns than if invested in equipment which might be operated with greater economy than that in existence. With business on somewhat closer margins and the present necessity of replacing or supplementing plant, consideration of gas engines using blast furnace gas is more serious.

Competition has sprung up also in the manufacture of large gas engines. The performance and detail construction of the engines offered for sale to-day is subjected to much closer scrutiny than usual in the purchase of steam engines for the same duty. At present, there are in this country no less than six firms, to my knowledge, who will undertake to furnish gas engines in sizes varying between 2000 hp. and 3000 hp.

A profitable market for power is essential before we may consider at all the use of surplus blast furnace gas for the development of power. Without such a market, the replacement of steam blowing engines by gas-driven blowing engines, in order to make a larger surplus available, should not, at present prices for equipment, be considered. If, for example, a blast furnace plant is not operated in connection with steel works nor in the vicinity of works which do or may use large quantities of power, no use could be found for the surplus gas which would be made available by the installation of gas blowing engines. In such a case, there would be no good grounds for recommending gas engine blowing equipment, unless the cost were less than that of the equivalent steam blowing equipment, including boilers. If, however, a market is within economical transmission distance, and other conditions are not prohibitive, very satisfactory returns may be expected.

An important and, in most cases, essential condition with which a power plant must comply, is that of uninterrupted service. The power plant which we consider here depends for its supply of gas upon the blast furnace, the heir to many ills. It may be put out of blast because the lining is worn out, or banked because there is a shortage of coke or other raw material, or it may be banked or put out of blast because of trade conditions, or on account of labor troubles, or there may be a stoppage of greater or less duration due to accident or trouble in the working of the furnace, and in its regular operation as well, the result of which is a suspension of its function of gas producer.

To secure, within a reasonable degree of certainty, a continuity of supply, no group of less than three blast furnaces can be considered as available to supply a power plant, which is intended to produce power for the general market. At any group of furnaces at least one will at some time be out of blast for relining, and at least one other furnace may be stopped for some one of the other reasons given above. With a group of three blast furnaces, therefore, the surplus gas of one will always be available.

With groups of more than three, still greater security against interruption would result, if we assume one furnace out of blast and two temporarily stopped. The percentage of surplus gas actually available from any group of N furnaces may be expressed by the formula,

$$\frac{N-3}{N} \times 100$$

in which, if values of "N" from 4 to 11 be substituted, the curve shown in Fig. 1 will be obtained. For the special case of a group of three furnaces, the surplus available becomes 33
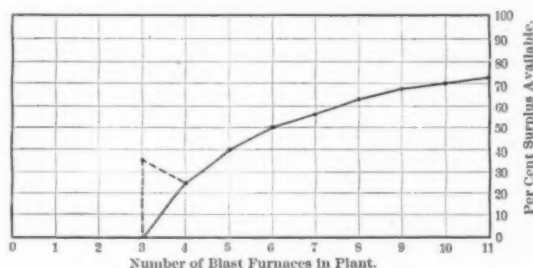

FIG. 1.—SURPLUS GAS AVAILABLE WITH DIFFERENT NUMBERS OF BLAST FURNACES.

per cent. To be even more conservative, two furnaces might be assumed as out of blast for relining at the same time, but with a power plant dependent upon the blast furnace plant, repairs of this kind can be so timed that it will not be necessary to reline two furnaces at once.

The value of a large number of units to obtain a given output of iron is very evident, if the development of a large percentage of the surplus gas into power is to be made possible. Increased cost of construction and operation of a blast furnace plant, made up of a number of small units, as compared with the same items of expense for a plant of the same capacity made up of large units, must be more than balanced by the profits which are to be realized from the operation of the larger power plant. Further than this, the prices obtained for the power must warrant the continuance in blast of all but one furnace of a blast furnace plant, when trade conditions would imperatively dictate a suspension of operation. The profit must at least pay the interest on the labor and material invested in manufacturing periods in which there is no market for the product and at least part of the loss due to a falling market.

With proper foresight in location and intelligent design we can eliminate from water-power plants every probable cause for a suspension. The labor question enters into it only to a very small degree. It looms up larger in the steam and gas producer power plants, owing to their dependence upon a supply of coal, into which the labor element of mining and transportation enter. The blast furnace gas power plant, however, is burdened with the responsibility of maintaining operations in spite of trouble which may occur at ore, stone and coal mines, coke ovens, along the lines of transportation, and finally at the blast furnace plant itself. Nor is this minimized to any great extent by the large stock carried in the furnace yards, for the troubles may occur at the end of the winter when the stock are low and no estimate, with any accuracy, can be made as to how long the trouble may last.

To meet such an emergency a gas producer plant might be installed. Even this would be but a partial remedy, and would involve an additional yearly charge for power of not less than

$7.50 per hp. or $10.00 per kw., not including the cost of any coal which may be consumed by such a plant to maintain at least a portion of it in readiness, or that required during such periods that the blast furnaces are unable to supply gas.
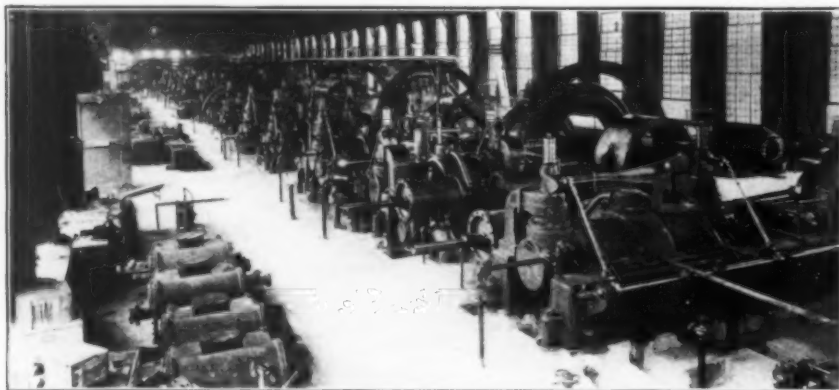
Without wishing to discourage the idea of building commercial power plants in connection with blast furnace plants, I believe it better to point out as clearly as possible all the disadvantages in the first instance, and leave to the decision of the investor whether the possibilities, as I shall attempt to show them, sufficiently outweigh the disadvantages, to en-


BLAST FURNACE GAS ENGINE POWER PLANT, CAPACITY 9000 HP.

courage him to venture capital in this rather than some other undertaking.

The amount of surplus energy and the proportion available for the development of power, is to be determined. The waste gases of the blast furnace contain about one-half of the total heat originally possessed by the fuel, and is approximately in direct proportion to the coke consumption per ton of iron. It has been variously estimated that from 18 per cent to 33 per cent of this heat is required to heat the blast. Not only have no accurate determinations ever been, to my knowledge, made of the gas consumed in hot blast stoves, but the heat which is to be imparted to the blast varies with local conditions, even when the final temperature is identical.

The distance between engines and stoves, the size of mains, the efficiency of burners and of the heating apparatus itself, materially affect the heat consumption. Differences in blast furnace practice result in different pressures, and the range in temperatures employed is by no means inconsiderable. A conservative estimate of the percentage of the heat of the waste gases to heat the blast would be 30 per cent, and one which would not, in general practice, be exceeded. For the compression of the blast by steam engines, giving an economy of 20 pounds of steam per hp. per hour when run condensing, under normal conditions, with boilers which convert 60 per cent to 70 per cent of the heat of the gas burnt into heat of steam, requires from 33 per cent to 40 per cent of the heat of the waste gases. For auxiliary purposes, such as pumps, light, power for

hoists and ore-handling machinery, approximately 7 per cent to 10 per cent is required. By the substitution of gas blowing engines and gas engines for the production of power for auxiliaries, the figures above may be reduced to read 16.5 per cent to 20 per cent and 3.5 per cent to 5 per cent, which, for clearness, are summarized in Table I.

The wide difference between the surplus available under the head of steam engines, is due principally to differences in efficiency of apparatus and only in a limited degree to differences in practice. The difference in surplus available under the head of gas engines, depends almost entirely on differences in furnace practice, for the efficiency of the gas engine equipment is in each case the same. The maximum surplus with steam equipment is, curious to say, identical with the minimum to be expected with gas engine equipment.

The superiority of the gas engine over the steam engine may appear rather small, when the figures given in Table I are compared with those frequently seen as the results of published tests. It must be remembered, however, that the gas blowing engine operates normally at

TABLE I.

Use.	Steam Engines.		Gas Engines.	
	%	%	%	%
Heating the blast	18	to 33	18.0	to 33
Compressing the blast	33	to 40	16.5	to 20
Auxiliaries	7	to 10	3.5	to 5
Surplus available	42	to 17	52.0	to 42
	100	100	100	100
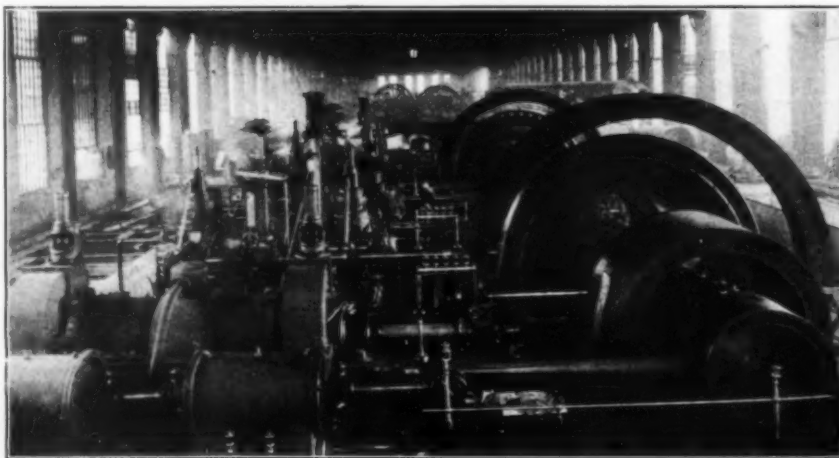
BLAST FURNACE GAS ENGINES NOS. 6 AND 7 OF 9000-HP. PLANT.
Absence of arms of fly-wheels indicates both engines in operation. Engine No. 7, in foreground, is the first large blast-furnace gas engine installed and operated in this country, first started January 2, 1903, and in regular service ever since.

only about two-thirds of the load which it must be designed to carry when the blast pressure reaches 25 pounds to the square inch. Such periods of high pressure may be coincident with a poor quality of gas, making the conditions even worse than indicated above. The gas engine in such service is at a disadvantage compared with a steam engine, designed to operate with

economy at normal load, with capacity, however, to supply air at the highest pressures met with in general practice.

Large gas engines are built to-day, which will, at full load, give a duty of 194,000,000 effective foot pounds, as compared with a duty of 82,000,000 effective foot pounds, from one of the best steam engines per 1,000,000 B. T. U. in the gas consumed in each case. As the economy of the gas blowing engine will approximate only 80 per cent of the figure given above, it may readily be seen that its ultimate economy, in blowing engine practice, may be safely said not to exceed twice that of the steam engine.

The actual amount of power available from the surplus gas developed by gas engines will vary with the coke consumed per ton of iron and the efficiency of engine and load factor. The coke consumption per ton of iron may be within a comparatively short time reduced to an average figure of 1700 pounds, as the result of the method which has recently been developed to remove the moisture from the blast. On the other hand, where the mixture is poor and other conditions unfavorable, the coke consumption may be as high as 2800 pounds per ton of iron. There will be present in the waste gases for the one case 9,000,000 B. T. U., and for the other, 18,000,000 B. T. U. per ton of iron.

The average of present practice in coke consumption is probably very close to 2240 pounds per ton yielding 14,000,000 B. T. U. in waste gases. We may reasonably expect a reduction of this figure to that of 1700 pounds, as stated above, but, on the other hand, improvements in engine and stove economy, which are to be anticipated, may permit the use of the larger figure given in Table I as the percentage of surplus gas avail-
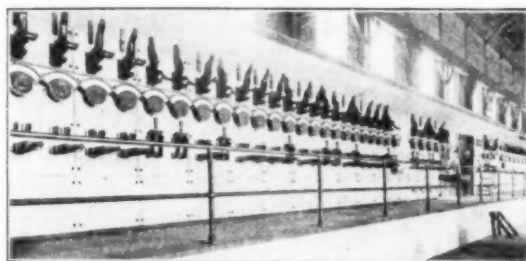
PORTION OF SWITCHBOARD FOR 900-HP. POWER PLANT SUPPLIED WITH BLAST FURNACE GAS ENGINES OF 1000 HP.

able with gas engines. The amount of surplus heat available for power per ton of iron may, therefore, be taken as 52 per cent of 9,000,000 B. T. U. or 4,680,000.

From this amount of heat it is possible to develop 468 hp. per ton of iron made per hour, with gas engines, which have a thermal efficiency per effective hp. of 25 per cent, or can produce one effective hp. per 10,000 B. T. U. per hour. Manufacturers of gas engines are willing to guarantee this result when their engines are operated at full load. For a blast furnace making 300 tons of iron per day, we may rely with certainty upon obtaining not less than

$$\frac{300 \text{ tons}}{24 \text{ hours}} \times 468 \text{ hp.} = 5850 \text{ hp.}$$

or let us say 6000 hp.

I shall not attempt to discuss here the details of engine construction nor any of the claims to excellence of the several makes of large gas engines, for these have been quite fully set forth in periodical literature, as well as the catalogues of the builders.

The subject of gas cleaning, however, is of great importance and merits some attention at this point. It is now generally conceded that blast furnace gas must be cleaned before use in the gas engines; if for no other reason than that the cleaning process, at the same time, reduces its temperature and thus

increases its density, thereby increasing the power available from a cylinder of given dimensions. Whether cleaned by transmission through great length of pipe at low velocity, or by contact with sprays or surfaces of water, the temperature is lowered. Cooling and cleaning by the dry or transmission method is not satisfactory, and becomes very costly if a temperature below 120° F. is desired. Nor do conditions of velocity, satisfactory for cooling, permit the settling of the dust, and the finest particles, when dry, require practically absolute rest, which is, of course, impossible. Water cooling and washing is now generally employed.

Electrostatic methods of cleaning have been suggested and experimented with, but so far as I am informed no practical results have as yet been obtained. In any event the gas for gas engines must be cooled. Cooling not only increases the density of the gas itself, but removes by condensation the moisture which is brought over with the gases from the ore, limestone and coke amounting to between 3 and 5 per cent by volume, reducing the heating value of the gas to that extent. The temperature of the gas must be lowered as much as the temperature of the water available, and the quantity which it is practicable to use, will permit, so that the gas at this temperature, when saturated, shall not contain more moisture than previous to treatment.

Various means have been employed to produce an intimate mixture of the cooling water and the dust-bearing gas. At first the old coke scrubber of coal-gas works practice was used, consisting of a vertical pipe filled with coke through which water trickled from above, and gas was made to pass from below. In order to overcome the resistance to the passage of the gas through the coke, either a steam jet blower or centrifugal fan was used. It was found that the dust adhered to the blades of the fan, and to avoid frequent stoppages for cleaning, water was introduced at the center of the fan to wash the dust away. Not only did this water keep the fan clean, but being dashed into fine particles by the action of the arm and blades, became intimately mixed with the gas and dust, reducing their temperature. The action of centrifugal force, assisted also to separate the particles of water and moistened dust from the current of gas. The mixture of water and dust was very readily flushed out of the fan. We thus owe to accident the most effective form of gas washer that has yet been devised.

Improvements have been made in details, making it more efficient, but in essentials the apparatus as first used remains to-day unchanged. More or less fine spray or mist of water is delivered by the fan with the gas and some form of separator, either of a type similar to steam separators and exhaust steam heads, or else a dryer in the form of a saw-dust box is placed in the gas main between the fan and the engine to remove it. The presence of mist in the gas is objectionable, because it may accumulate in the gas mains, freeze in winter or at any time it may be carried into the motor cylinder, cause difficulty in ignition, or absorb a certain quantity of latent heat when converted into steam by the combustion of the gas with which it is mixed.

The equipment of fans required and the consequent cost of power may be materially lessened by the introduction of precooling devices, relying on the fans principally for the separation of the water and dust from the gas. These pre-coolers may take the form of horizontal pipes, equipped with water sprays or vertical pipes or towers similarly equipped and arranged so that the gas moves upward against the sprays. The gas in this way not only comes in contact with each successive spray, but by the action of the drops of water, owing to the longer time which they are exposed to the gas in falling through it, reduce the temperature and moisten the dust much more effectively in a vertical than in a horizontal spray pipe.

The action of the sprays, however, is to beat the gas back so that as a matter of fact the fan motors must exert some power to draw the gas through the towers. This fact is evidenced by an inflow of air through any opening at the top of the tower,

where, if there were any of the pressure such as exists at the top of the blast furnace, there would be an outflow of gas. The expenditure of power to draw the gas through the tower is less than that required to accelerate the gas and water required for cooling in a fan, should the pre-cooling towers be omitted. The water consumption is approximately 0.06 gallons per hp. per minute, and the fan, motors and pumps take about 1.3 per cent of the rated hp. of the gas engine installation which they serve.

The degree of purity necessary will depend to some extent upon the type of engine in which it is to be used. The two-cycle gas engine equipped with gas pumps provided with piston valves must be supplied with purer gas than four-cycle engines which take their supply through the motor cylinder only. Entire exemption from troubles incident to the presence of dust in the gas may be avoided, if the purity is so high that the gas contains no more than 0.025 grams per cubic meter. A very simple apparatus has been devised, which has made possible accurate and rapid determinations of the quantity of dust present in the gas. It is highly important to determine the quantity and character of the dust, and to study carefully in each case all the local conditions before any attempt is made to design a gas-washing plant.

Any variation in the composition of the gas affects, to some extent, the regulation. Especially is this true when this change in composition consists in a sudden increase in the percentage of hydrogen, due to a leak in some cooling device which permits water to enter the furnace. At present there are no means known by which the power plant may be warned of its approach in the current of gas. By means of the composimeter changes in the calorific value of the gas, other than those due to hydrogen, are at all times indicated, and the power house would in most cases have time to start up a reserve unit when the calorific value of the gas falls to a point below which the full power of the engine cannot be developed.

Without uniformity of gas pressure, regulation sufficiently close to insure successful operation in parallel of alternating-current generators, is extremely difficult, if not impossible. The use of a gas holder affords a simple means of maintaining a constant pressure, and provides some little storage room as well. Changes in the operation of the blast furnace and variations in the consumption of gas by the engines are too frequent and rapid to permit at present of any satisfactory method of regulation at the fan. The cost of the gas holder of sufficient capacity to maintain even for one hour a supply of gas for the plant at full load, when all the blast furnaces are stopped, would not, except in special cases, be warranted, and in general the use of a large gas holder is unnecessary.

In order to give the power proposition every benefit obtainable, we shall consider only the largest units at present obtainable. I have elsewhere stated that builders are prepared to furnish and guarantee the successful operation of gas engines ranging between 2000 hp. and 3000 hp. per unit.

The cost of plant and cost of power must be based on certain assumed conditions of service and load factor. We will assume, for example, that the character of the service which the power plant is to supply will involve suddenly applied though possibly momentary overloads of 50 per cent, and that the load factor is 50 per cent. As the gas engine has no overload capacity, or stated differently, we may say, that full load is the limit of its overload capacity, the nominal full rated load must be two-thirds of the actual full load capacity, for the case which has been assumed. A gas engine of 2000 effective hp., coupled to a 1000-kw generator, capable of momentary overloading to 50 per cent, would be a suitable combination. This class of service and type of unit will be designated as Class "A."

For service in which there is never any overload, or where the full load of the generator is but 80 per cent of the engine capacity and the generator overload never excedes 25 per cent, a 2000 effective hp. gas engine coupled to a generator of 1500

kw. would be a satisfactory unit, and we may designate this type and service as Class "B."

In either class the space occupied would practically be the same and require for each unit a length of 50 feet in a building 75 feet wide, together with some additional length to house

TABLE II.
Cost of Power Plant.

DATA.—Gas engines in both classes are 2000 hp. each. 75 r.p.m. One unit in each case in reserve.

Items.	Class "A" 4 1000-kw. Units, 50% Overload Capacity.	Class "B" 4 1500-kw. Units, No Overload Capacity.
Land..............................	$ 5,000	$ 5,000
Building............................	67,500	67,500
Engine Foundations................	6,000	6,000
Crane—Travelling.................	8,000	8,000
Piping.............................	16,000	16,000
Compressors and Engines.........	8,000	8,000
Pumps and Engines...............	12,000	12,000
Exciters and Engines..............	15,000	15,000
Switchboard—Wiring—Lamps.....	16,000	16,000
Generators........................	100,000	120,000
Gas Engines......................	280,000	280,000
Exhaust Stack.....................	4,000	4,000
Gas Washing Plant................	30,000	30,000
Gas Holder and Piping............	10,000	10,000
Office and Fixtures................	2,500	2,500
Total Cost......................	$580,000	$600,000
Cost per kw. of Total Station Capacity........................	145.00	100.00
Cost per kw. of Station Capacity Operated.....................	193.33	133.33

TABLE III.
Cost of Power at Station Switchboard.

DATA.—Gas engines in both classes are 2000 hp. each. 75 r.p.m. One unit in each case is in reserve. Value of blast furnace gas not considered.

	Class "A" 4 1000-kw. Units, 50% Overload Capacity. Load Factor 50% 24 Hour Power		Class "B" 4 1500-kw. Units, No Overload Capacity. Load Factor 80% 24 Hour Power.	
	Per Annum Amount Dollars	Per kw. Hour Cents	Per Annum Amount Dollars	Per kw. Hour Cents
Superintendence and Wages.................	$20,450	0.156	20,450	0.065
Supplies, including water	18,800	0.143	18,800	0.0597
Repairs and maintenance	11,600	0.0885	12,000	0.0382
Taxes and Insurance....	8,700	0.0665	9,000	0.0286
Capital Charges:				
5% on Investment....	29,000	0.578	30,000	0.248
8% Sinking Fund.....	46,800		48,000	
Total Cost.............	135,350	1.0320	138,250	0.4395
Cost per kw. year of station capacity operated		$45.12		$30.75
Cost per kw. year power generated.............		90.24		38.40
Assuming profit of 10% on Investment........	58,000		60,000	
Total Price.............	193,350	1.475	198,250	0.630
Price per kw. year power generated.............		$128.70		$55.15

the compressors, pumps and exciters which go to complete the installation. No proposition, except one which utilizes all the surplus gas upon which we can depend, need be considered here. Nor shall we consider blast furnaces producing less than 300 tons per day each; but this must not be taken to pre-

clude consideration, except in this particular case, of such a project for a group of smaller blast furnaces. The estimate here given is on a power plant in connection with a group of either three or four 300-ton furnaces, in which the surplus gas from one furnace only may be utilized.

The Tables II and III, on page 98, give in detail the estimated cost of installation and cost of power at the switchboard, and are based on actual experience which the writer has had in the construction of such plants. Sufficient allowance has been made to insure against variation in price and efficiency of labor and cost of materials. In Table III the annual amounts have been given, as well as the kw. rate, so that the reader may make his own assumptions as to the total current generated, and find the total cost per kw.-hour. The only variable is "Supplies." Unless the load factor is so low as to permit of stopping one of the three units which have in calculations been assumed as always in service, the value of "Supplies" will not vary appreciably.

The cost of installation compares favorably with that of the best steam plants, and we may expect to better the figures given. We cannot, however, look for any great reduction, and as the cost of operation is, to the extent of 70 per cent, made up of charges based on investment, we may say that the cost of $38.40 per kw.-year at the switchboard is susceptible of little, if any, improvement. By dropping the sinking fund rate to 2 per cent, the cost could only be reduced to $35.00.

As stated in Table III, no allowance has been made for the value of the blast furnace gas. If the surplus were not thus utilized for the development of power it would be lost. If the same amount of heat which is supplied by the blast furnace gas were obtained from coal at $2.00 per net ton or natural gas at 7 cents per 1000 cubic feet, the cost of fuel for the gas engine per kw. per year would be approximately $12.50 in either case. For the steam engine the expense would only in rare instances be less than $25.00.

The value of the surplus gas may also be taken as the sum of the capital charge of 5 per cent and the profits, amounting in Class "A" to $87,000, and in Class "B" to $90,000 per annum for a blast furnace plant, of which the yearly output is 300,000 tons of iron. An increase in profits to the iron manufacturer of approximately 30 cents per ton may thus be realized. If this is true of a plant which can convert but 25 per cent of the surplus gas available, still better results may be expected from those at which the percentage of surplus convertible, as indicated by Fig. 1, is greater. It would not be impossible to realize 75 cents or more per ton, where 8 to 10 furnaces are grouped. No management can well afford to neglect a very thorough investigation of the conditions at his plant and his locality to determine whether they are favorable to the development of power from surplus gas.

Wherever there is a large demand for power and cheap water-power is not available and blast furnaces are, the blast furnace gas engine power plant need fear no rival. We are not far from the day when the power house will be as much a part of every modern blast furnace plant as are the condenser and ammonia houses of the modern by-product coke plant.

RADIUM AND TERRESTRIAL HEAT.—C. Liebenow, in a paper in *Physikalische Zeitschrift*, vol. 5, No. 20, page 625, points out that a relatively very small quantity of radium in the earth would be sufficient to keep the temperature in it constant. The heat given off per second by the surface of the earth is about 10,000,000,000 kilogram-calories. Since 1 gram of radium produces 226 gram calories per hour, the earth cannot contain more than 200,000,000,000 kilograms of radium, as otherwise its temperature would continually rise. If this quantity was uniformly distributed throughout the earth, one cubic meter would contain 0.0002 milligram. Elster and Geitel have found a thousand times this amount in the soils investigated by them. The radium must therefore be distributed nearby the surface, about 0.4 gram per sq. meter.

Electrochemical Reactions in Solid Electrolytes.

BY PROF. F. HABER AND H. TOLLOCZKO.

Our knowledge and mastery of the processes in the electrolysis of solid bodies is very poor. That solid substances conduct currents, especially when they are heated, is well known, and there is no doubt as to the electrolytic nature of this conductivity, for chemical changes at the poles have often been observed qualitatively when a current passes through solid salts and the occurrence of counter electromotive forces (polarization) under these conditions has been proven. Such observations are found in the literature of the subject, partly in earlier times, and partly recently, in connection with the well-known technical results which have been brought to light through the application of solid electrolysis for lighting, in the Nernst lamp[1]. Quantitative study of the electrochemical changes in solid electrolytes, however, has hitherto been successfully carried through only in those cases in which it was possible by some special device to keep the electrolyte unchanged. Warburg achieved this by using ordinary heated glass as electrolyte, between an anode of sodium amalgam and a cathode of mercury. The glass remained unchanged, both under the microscope and to the naked eye, while a quantity of sodium, corresponding to Faraday's law, passed through it.

We have investigated this subject more closely, devoting ourselves especially to the electrolysis of solid barium chloride at about 400° below its melting point; that is to say, about 500° to 600° centigrade.

Barium chloride melts readily a little below 1000° to a clear liquid. For containing vessels we used nickel crucibles of common form (dia. 3.5 cm. at the top), which were connected with the positive pole of a source of current; while for counter-electrodes sticks of graphite, iron wires, or platinum wires, were dipped into the melted mass. Then we let the melt harden and cool off. Later we heated again to 500° or 600°, and this time passed the current through. We worked with current intensities which seldom exceeded 50 milliamperes and required pressures which seldom reached 20 volts, and for the most part amounted to less than 10 volts. The quantity of electricity used was measured with the copper coulometer (we use this expression, following the usage of Th. W. Richards, instead of the older designation "copper voltameter"). The counter electromotive force of polarization could be measured by means of the compensation method, after breaking the current. The heating of the crucible traversed by the current took place either by means of a little gas furnace, or in an electrical muffle. Particulars may be found in a detailed report, in the *Zeitschrift für Anorganische Chemie* (Vol. 41).

At the anode, that is, at the inside wall of the nickel crucible, nickel chloride ($NiCl_2$) was formed, in the anhydrous condition; as the electrolysis continued, it slowly grew into the interior of the solid barium chloride. Fortunately, it formed no dendrites, but penetrated only slightly and uniformly towards the interior of the mass of barium chloride. After the end of the electrolysis, when the block of barium chloride had been removed from the crucible, this layer containing the nickel could be easily scratched off. Then the block consisted of barium chloride, in which the cathodic products were enclosed.

One might at first suppose that barium would have gathered at the cathode. If this had been the case, then the polarization must have amounted to about 2.65 volts. For in this case, all the substances are in the solid condition, so that Thomson's rule may be applied to calculate the electromotive force from the heat reaction. With the help of this rule,

[1] See e. g. Hittorf. Pogg. Ann., 84 (1851) 1, Bose Druder's Ann., 9 (1902) 164, and summary of the literature in Wiedemann, Die Lehre von der Electricität, II. edi. Braunschweig, 1903, Vol. I., p. 545, and Vol. II., p. 491.

however, it is found from thermochemical data that 2.65 volts are required for the reaction

$$Ni + BaCl_2 = NiCl_2 + Ba \ldots\ldots\ldots\ldots(1)$$

But the polarization turned out to be considerably higher at the moment of breaking the current, and sank rapidly, without stopping at 2.65 volts, till it reached about 1.9 volts, where it remained steady for a long time. This behavior is readily explained when it is remembered that Guntz recently has shown that barium subchloride is formed from barium and barium chloride. The reaction follows the equation:

$$Ba + BaCl_2 = 2BaCl \ldots\ldots\ldots\ldots\ldots(2)$$

Barium in the presence of barium chloride is therefore unstable, and changes into the subchloride. It behaves, therefore, similarly to iron in contact with ferric chloride solution, or tin in contact with stannic chloride solution. In such a case theory[a] permits the prediction of certain values of the counter electromotive forces before and after breaking the current. As long as the current is flowing, and barium is present in addition to barium subchloride, the counter electromotive force of the reaction:

$$Ni + 2BaCl = NiCl_2 + 2Ba \ldots\ldots\ldots\ldots(3)$$

has to be overcome. As soon as the current stops, barium is consumed by the barium chloride according to reaction (2). After this there is only barium subchloride and barium chloride in contact with the electrode and the counter electromotive force corresponds to the equation:

$$Ni + 2BaCl_2 = NiCl_2 + 2BaCl \ldots\ldots\ldots\ldots(4)$$

It is easy to see that the electromotive force for reaction (4) must be less than that for (1), by just as much as the electromotive force for (3) exceeds that for (1). Now, we found, as mentioned above, an electromotive force of about 1.9 volts after breaking the current. We conclude from the considerations just adduced that this electromotive force must correspond to the reaction (4). Then reaction (3) must have the electromotive force 3.40 volts. The values of the polarization which are measured immediately after breaking the current will come the nearer to this value, the slower the reaction (2) takes place. In order to retard (2), we made use of the device of lettting the temperature sink during the electrolysis. In this manner we reached a point where we could observe 3.26 volts of counter electromotive force immediately after breaking the current.

This value is as near to the calculated amount of 3.40 volts as can be expected, in view of the uncertainty in the thermal data on which the calculation is based, and in view of possible small deviations from Thomson's rule.

It must accordingly be concluded that in the electrolysis barium was produced, which soon united with the barium chloride to form barium subchloride. More exact discussion of the numbers given shows that the subchloride must be able to decompose water with great activity, producing barium hydroxide, barium chloride, and hydrogen. It is therefore not in the least strange that the production of the subchloride in aqueous solutions does not succeed any better than the electrolytic separation of aluminium from aqueous solutions of salts of alumina, or the separation of free fluorine from aqueous solutions of fluorides. On the other hand, this offers the possibility of determining the quantity of barium subchloride produced by the current, if quantative measurement is made either of the hydrogen or of the barium hydroxide produced when the mass is dissolved in water. The determination of the hydrogen is of use only when care is taken to prevent the access of oxygen to the subchloride, both during the electrolysis and subsequent operations. The moisture of the atmosphere must also be carefully avoided. The quantity of barium hydroxide, which is found after dissolving the mass in water, must, however, always permit a conclusion to be drawn as to the amount of BaCl produced by the current. Now we have been able to show that the quantity of this bari-

[a] The underlying theoretical views were first given by Luther (Zeitschr. Physic. Chemie, 30, 660 [1899].)

um hydroxide came extraordinarily near to the theoretical value, so that we may say: *The formation of barium subchloride at the cathode took place according to Faraday's law.*

We were able to bring about a different action at the cathode, by adding barium carbonate to the barium chloride during the melting. In this case carbon appeared at the cathode, in quantity corresponding to Faraday's law. This carbon formed dendrites, which grew upon the cathode in the direction of the lines of flow of the current. It was easy to separate it by dissolving the melt and collecting the undissolved black residue. The carbon could be determined quantitatively, both from the loss of weight in heating this residue to redness, and from the carbon dioxide produced in its elementary analysis. The counter electromotive force, when carbon is produced, can be calculated by means of Thomson's formula, from the heat of the reaction:

$$2Ni + BaCO_3 + 2BaCl_2 = 2NiCl_2 + C + 3BaO$$

It comes out about 1.6 volts. We found, in agreement with this, that the polarization after breaking the current does in fact reach a stable value between 1.5 and 1.6 volts.

The action when carbon is produced at the cathode may be conceived as consisting at first of the production of barium, which then reacts according to the equation:

$$2Ba + BaCO_3 = 3BaO + C$$
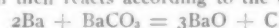
In order to justify this equation, we have demonstrated that sodium readily separates carbon from barium carbonate when the two substances are heated together. This is an experiment which is quite simple to carry out. We arranged it as follows: Barium chloride and barium carbonate were melted together in a porcelain crucible, and during the cooling the crucible was rocked. In this manner the inside of the crucible was coated with a protecting layer of the carbonate and chloride of barium, which formed a hollow. In this hollow we laid a piece of sodium, covered it with barium carbonate, and heated with a small gas burner, at the same time passing nitrogen over the top, to avoid oxidation. After a few minutes the sodium disappeared, and a considerable quantity of carbon was separated.

If pure barium chloride is melted in the nickel crucible, and electrolysis is carried out, after it has become hard, then also carbon will be found at the cathode, in case the melting took place in a gas furnace. The reason for this is that the combustion gases change melting barium chloride into barium carbonate, with loss of chlorine. This remarkable reaction, to which we have devoted special experiments, takes place according to the equation:

$$BaCl_2 + O + CO_2 = BaCO_3 + Cl_2$$
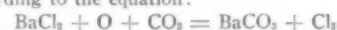
Melting calcium chloride shows the same reaction, to an even greater degree; and even in the case of common salt we were able to demonstrate a slight formation of sodium carbonate and chlorine gas under similar conditions.

We have been describing a few cases of solid electrolysis, which, so far as we know, are the first of their kind. To supplement the observations made in this connection, we have carried out a few experiments with reference to the electromotive forces of electric cells consisting entirely of hot solid salts and solid metals. A good example of such a battery is:

Lead—Lead chloride.   Silver chloride—Silver
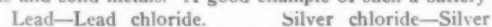
This battery can be easily investigated between 150° and 250° centigrade. Its voltage was near to that calculated from Thomson's rule for the reaction:

$$Pb + 2AgCl = PbCl_2 + 2Ag$$

But the temperature coefficient turns out not to be zero, but has a small measurable value. This is related to certain theoretical considerations, regarding which we refer to the detailed publication in German, cited before. Our experiments on this branch of the subject are not yet completed.

We believe that the electrochemical phenomena described in this article show that the electrolysis of solid substances deserves greater interest. We have very few other ways to

study the reactions between solid substances. And these re-actions deserve special attention, because the mass actions which are inseparable from the reactions in the dissolved, melted, or gaseous states, either disappear in the case of solids, or else assume special and interesting forms. Also, as the example of the electrolytic separation of carbon shows, we may expect some results which have hitherto not been at-tained in other ways.

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Equipment of a Laboratory for a Smelting Plant.

In a paper presented at the Lake Superior meeting of the American Institute of Mining Engineers, Mr. HERBERT HAAS describes a laboratory for metallurgical chemistry and tech-nical analysis, which he built late in 1903 for a pyrite smelter at the Afterthought mine, Ingot, Shasta County, California.

A works-chemist, having the shortest time in which to make his determinations, should have a laboratory arranged as conveniently as possible to save time in carrying out his work. It is not uncommon at large smelters to have the night-assayer prepare thirty or more samples for titration in time for the chemist to begin work on them at 7 o'clock on the following morning. During the time that the solu-tions are being heated on the hot-plate, the chemist is weigh-ing out portions of slag-samples which have been taken from each furnace. As a rule, he determines the various per-centages of silica, iron and lime in the slag (the values in lead and silver, and sometimes that of gold being determined by the assayer), but very frequently the slag is analyzed for other constituents as well; and every fourteen days a com-plete analysis of it is made. The chemist cannot give his entire time to a single analysis until it is completed, for the reason that a dozen or more additional samples come in regu-

light and good ventilation, because, even with the best ar-rangement of hoods and flues, the air is liable to become contaminated by acid fumes.

The laboratory building is constructed of wood, and is ceiled inside with tongue and groove lumber, leaving a 4-inch air space between the outer and inner walls. The roof ter-minates in a large ventilator, having windows swinging on pivots over the laboratory portion, while over the assay office the ventilator has fixed shutters of 1 x 6 inch wooden slats, set at an angle of 45°, with 3-inch spaces between adjacent slats. A chemist's hearth having a hood supplies the heat necessary to boil solutions, as well as for other uses. The main working table is placed opposite the chemist's hearth, which arrangement allows the chemist to carry on his analy-tical work, and, at the same time, to control the heating of the samples in sight on the hearth. The table is equipped on both sides with drawers, closets and shelves; the side nearest the hearth is used for quantitative work only, while on the other is a complete set of the reagents needed for qualitative min-eral analysis. A small kerosene stove and a copper kettle, placed on the highest shelf of the table, gives a constant sup-ply of hot distilled water. On opposite sides of the bottom of the kettle are two small bibbs, to which are fastened small rubber tubes, having at each outer end a pointed glass tube, and sufficiently long to reach both ends of the table. A Mohr "pinch" cock regulates the flow of water to a nicety, and the 4-foot head gives sufficient pressure to wash thor-oughly and quickly precipitates, filters, etc. This arrangement avoids the discomfort arising from continued inflation of the cheeks which the ordinary wash-bottle necessitates. A sink of glazed clay with drainboards is placed at the end of the table.

A table opposite the main working table is reserved for electrolytic analysis, and is equipped with an accumulator, which is used as the source of current. The current strength
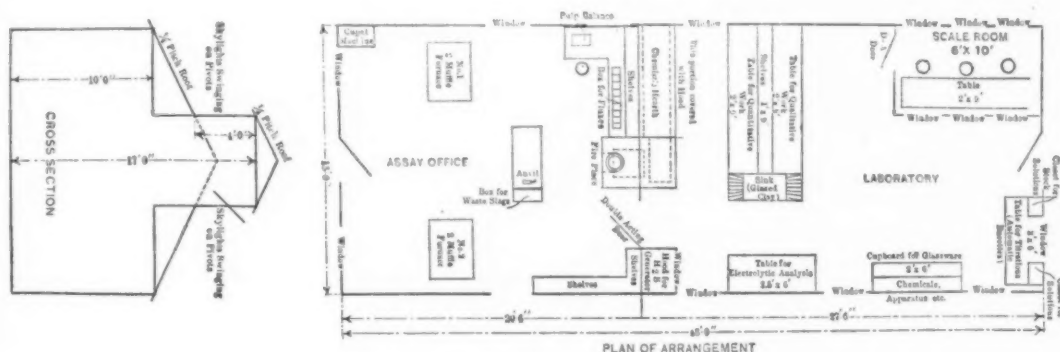

FIG. 1.—GENERAL ARRANGEMENT OF LABORATORY AND ASSAY OFFICE FOR A SMELTING PLANT.

larly which have to be analyzed for "insolubles," silica, iron, lime, zinc, sulphur, lead, copper, alumina, manganese, ar-senic and antimony.

Every fourteen days, both flue-dust and speiss are tested for their copper and lead contents, and occasionally a com-plete analysis of these products is required. The lead bullion is analyzed for its content of iron, copper, arsenic, antimony and bismuth. In addition to the routine work mentioned above, an analysis of coal or coke for the percentage of ash, sulphur, volatile matter and fixed carbon, as well as a de-termination of its calorific value, is called for, and occasion-ally an analysis is made of refractory brick and of gas. The chemist, in order to do all this work, must devote his entire time for ten hours every day. The above-named conditions are not hypothetical, but have actually occurred in the au-thor's own experience at a large lead smelter.

The chief requisites for a works laboratory are aboundant

and potential respectively measured by an ammeter with a range of 5 amperes, and sub-divisions of 0.1 ampere, and a voltmeter with a range of 10 volts, and sub-divisions of 0.1 volt. The rheostat consists of a band of German silver placed in the circuit and having a sliding contact enables the operator to change the potential. As the electrolytic deter-minations are limited to copper mattes, and occasionally leaf copper for standardizing purposes, the amperage and voltage best suited to the chemical composition of the matte will be used, and when once ascertained, they will remain practically constant. Luckow's cylinder and spiral are used as electrodes.

A table in front of a window is used for titrations and is provided with burettes, which can be filled automatically. This special type of burette consists of a two-liter glass bot-tle with a pressure and a delivery tube passing through the cork, the delivery tube connecting direct to the upper end of burette. The presseure necessary to force the solution

from the bottle to the burette is supplied by two rubber bulbs having air inlet valves so arranged that a continuous pressure may be produced. The inner (and larger) bulb is covered with a strong cord net in order to remove the danger of bursting from too great a pressure. On the table are two closets, having shelves large enough to hold a two-quart bottle, and serving the purpose of keeping the solutions in the dark; the closet doors bear the symbols of the respective stock solutions. In his laboratory the author has the following-named stock solutions, potassium cyanide, potassium dichromate, potassium permanganate, potassium ferro-cyanide, N/10 potassium hydroxide, N/10 sulphuric acid, copper sulphate, ammonium molybdate. An additional set of these so-
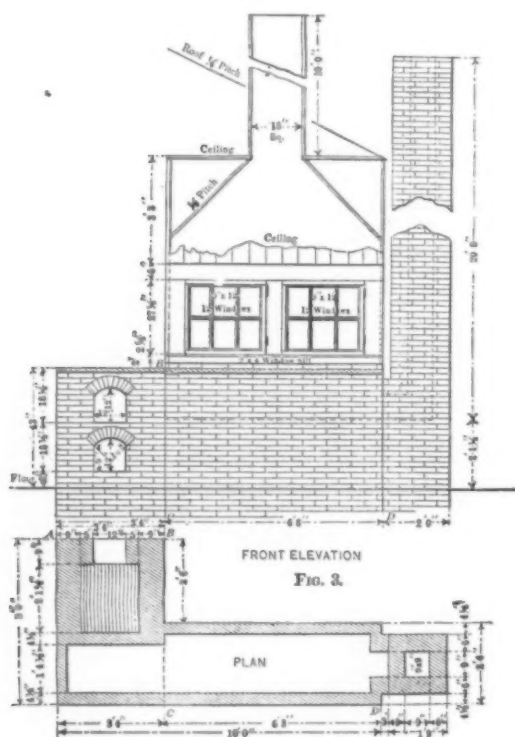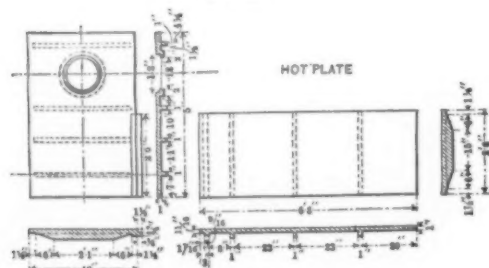

FIG. 2.

FRONT ELEVATION

FIG. 3.

PLAN

FIG. 4.

HOT PLATE

FIGS. 2, 3, 4—DETAILS OF THE CHEMIST'S HEARTH.

lutions kept in reserve in the dark closet allows a convenient interval of time in which to prepare fresh solutions.

A cupboard is provided in which to store a complete set of the chemicals needed in this line of work, as well as such apparatus and glassware as are only occasionally used.

The balance-room is tightly ceiled, special care having been taken to make it dust-proof. It has three windows on each long side, and a swinging sash-door entrance at the end, which guards against collisions between assayer and chemist

when passing through the door-way in opposite directions.

The bench on which the balances rest is suported by wooden posts set in concrete, and extending through the floor to the ground with a 0.25-inch clearance. The scales set on plate glass, when once adjusted, remain level for a considerable time, any shrinkage of the table having no effect on the position of the plane of the plate glass.

The general arrangement of the laboratory and assay office is shown in Fig. 1.

The chemist's hearth, a description of which may possess special interest to chemists, and metallurgists at places where gas is not obtainable, is illustrated by Fig. 2. This hearth rests on the ground and the flue from it is filled with ashes and earth to within 18 inches of the hot-plate. In the front of the ash-pit, beneath the assay office floor, is a 12 x 12 inch opening, which is closed with a piece of sheet iron luted on with clay. The accumulated ashes in the ash-pit are removed through this opening, thus avoiding their removal through the assay office. The ash-pit door, shown in the drawing, is used solely to regulate the draft. Old rails, preferably, are used as grate bars.

The front elevation of the hearth is shown in Fig. 2, which includes also the elevation of the fireplace front, with the ash-pit door and the feed door. The lines AB and CD, explain the respective elevations. The walls of the hearth consist of one course of brick, excepting at the stack, which is of a course and a half, and the fire-box, which is of two courses. These walls support the hot-plate, having its upper surface 43 inches above the level of the floor. A detailed dimensioned drawing of the hot-plate is given in Fig. 4. The plate is cast in two places, having a lap so that a tight joint may be obtained, and at given intervals ribs are cast as a safeguard against warping. A circular hole, over which the still is placed, is left in the plate. A portion of the hot-plate 2.5 feet by 6 feet 8 inches, is covered with a hood, which rests on one layer of bricks, except at the hottest parts, where there are two layers in order to protect the wood. The back side of the hood does not rest on bricks, but is separated from the plate by a 2-inch air space extending the entire length of 6 feet 8 inches. Access to the hot-plate is obtained through two windows, each having twelve lights of glass and hinge on butts. The hood is tightly ceiled with tongue and groove lumber, and has an 18 x 18 inch wooden chimney, 10 feet high, to carry off the fumes. The temperature of the inside of the hood and hood chimney is sufficient to draw in fresh air constantly and thus improve the ventilation of the laboratory.

The great advantage of the hot-plate is in its gradual decrease in temperature towards the chimney. The heating of solutions is generally started at the coolest place, and gradually continued toward the hottest part. The heat is diffused over a large area, and is not concentrated at one small spot, as is the case with a Bunsen burner; and the boiling over of solutions is thus easily avoided at the expenditure of the least attention and care; this allows the chemist time in which to attend to other work. A small, uncovered portion, 2.5 feet by 3 feet 4 inches, is reserved for operations which are preferably conducted in the open air. The fire-place extends into the assay office, and is closed off from the laboratory by a ceiled partition, formed by the continuation of the back side of the hood.

A still, placed over the circular hole described above, provides the laboratory with about 14 gallons of distilled water daily. The still now used is called the Cuprigraph Sanitary Still, No. 11, and when once regulated requires very little additional attention. The hearth thus serves two purposes, one to provide the laboratory with distilled water, and the other to give the chemist, at the same time, a very efficient way of heating solutions. The distillation of the water utilizes much of the heat, yet the hearth is necessarily wasteful, the flue being too short for economizing fuel. The weekly fuel consumption, however, is only from one-half to three-quarters

of a cord of wood, which, at $4.00 a cord, is equivalent to an operating expense of from 28 to 42 cents a day.

Fig. 5 shows the decrease in temperature with increasing distance from the fire-place. The temperatures were taken with a thermometer registering up to 250° C., and, while the readings are not exact, because the hearth was fired intermittently, they convey a fairly true idea of the temperature at different portions of the plate. Generally, the hot-plate is not used at temperatures as high as those recorded.

The laboratory is also provided with a hood, containing a hydrogen sulphide generator.

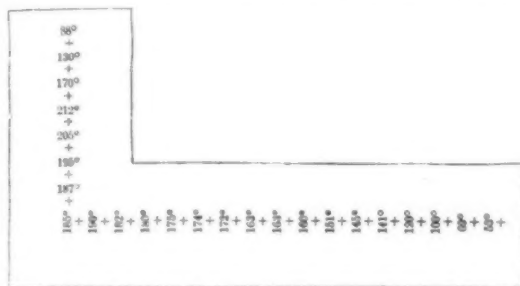The assay office has two muffle furnaces, one kept as a re-

FIG. 5.—TEMPERATURES IN DEGREES C. AT DIFFERENT PARTS OF THE HOT PLATE.

serve, or used when an accumulation of work has to be done. A general fluxing mixture is kept, which, with slight alterations, can be used to flux ordinary ores.

All the samples are received from the sampling mill in a ground condition passed through a 100 or 125 mesh sieve. No grinding or sampling is done in the assay office. The cupels are made by a cupel machine.

The cost of the assay office and laboratory (not including chemical apparatus and supplies) was a little below $525, while the cost of the chemist's hearth was $142.

Metallurgical Calculations—I.

BY J. W. RICHARDS, PH. D.
Professor of Metallurgy in Lehigh University.

Introduction.

The making of calculations respecting the quantitative working of any process, furnace or piece of apparatus used in metallurgical operations is of the greatest importance for estimating the real efficiency of the process, for determining avenues of waste and possible lines of improvement, and for obtaining the best possible comprehension of the real principles of operation involved.

The possibility of making such calculations respecting any process, furnace or apparatus depends on skill in collecting such necessary data as can be obtained by observation or measurement, the insight or intuition to see the further use which can be made of said data when once obtained, and, finally on the possession of a working knowledge of the fundamental chemical, physical and mechanical principles involved in the calculations. The highest desideratum, all in all, however, is a plain analytical, common sense mind, capable of clear, logical thinking. It is the writer's conviction that no study of details, or even observation of plants in actual operation, can supply the insight into metallurgical processes and principles, such as is gained by these calculations, in addition to the high grade of mental training involved.

Scope of the Treatise.

Discussion of the chemical equation.
Weights and volumes of gases.
Correction of gas volumes for temperature and pressure.
Combustion of commercial fuels.

Heat of chemical combination; of combustion.
Theoretical flame temperatures:
    With pure oxygen.
    With ordinary air.
    With diluted air: Farley's system.
    With hot air and cold gas
    With hot air and hot gas.
    Effect of excess air.
Calculation of furnace efficiencies.
Chimney draft.
Transmission of heat through metals, brick, etc.,
Water gas.
Producer gas: Efficiency, effect of drying.
Mixed gas:
    Use of steam in producers.
    Increased efficiency.
    Maximum steam permissible.
Regenerative gas furnaces:
    Proportioning of gas and air regenerators.
    Efficiency of generators.
    Heat balance sheet.
    Theoretical temperatures under different conditions.
Gas engines:
    Calculation of temperatures in cylinder.
    Efficiency; balance sheet.
Cupolas: Amount of blast required.
    Efficiency of running.
Blast furnaces:
    Balance sheet of materials.
    Calculation of blast received.
    Efficiency of blowing engines.
    Power and dimensions of blowing engines.
    Carbon consumed at tuyeres.
    Effect of atmospheric changes.
    Effect of the moisture in the blast.
    Calculation of the temperature.
    Effect of hot-blast.
    Heat balance sheet of the furnace.
    Power producible from the waste gases.
Hot-blast stoves: Theory of iron-pipe and fire-brick stoves.
    Efficiency.
Bessemer Converters:
    Blast required and time of operation.
    Balance sheet of materials.
    Heating efficiency of various ingredients of bath.
    Heat balance sheet.
    Theoretical rise in temperature.
    Conversion of copper matte.
Open-hearth Furnaces:
    Pig and ore process; calculation of charge.
    Heat evolved or absorbed in bath reactions.
    Efficiency of furnaces; of furnaces and producers.
    Heat balance sheet.
Electric furnaces:
    Working temperatures.
    Heat balance sheet.
    Efficiency.
Electrolytic furnaces:
    Absorption of heat in chemical decompositions.
    Equilibrium of temperature attained.
    Ampere and energy efficiency.
Electrolytic refining:
    Calculation of plant and output.
    Power requirements; temperature of baths.
    Ampere and energy efficiency.
Condensation of metallic vapors:
    Principles involved.
    Application to condensation of zinc and mercury.

[As this treatise on metallurgical calculations is not now written, but is being written as it appears in this journal, the above plan may be only followed in general, and additions or variations introduced as seems best, as the work progresses.

The above gives, however, some idea of the scope of the work and the field which will be covered. Any suggestions from readers, as to important fields for calculation not mentioned, will be gratefully received and included in the scope of the treatise, if practicable.]

The Chemical Equation.

The calculation of the quantitative side of many metallurgical processes depends upon the correct understanding of chemical equations. Every chemical equation is capable of giving three most important sets of data concerning the process which it represents; it shows the relative weights of the reacting substances, their relative volumes, when in the gaseous state, and the surplus or deficit of energy involved in the reaction, when the heats of formation of the substances concerned are known.

ATOMIC WEIGHTS.

These are the basis of all quantitative chemical calculations. For metallurgical purposes we may use them in round numbers as:

Hydrogen	H	1
Lithium	Li	7
Beryllium	Be	9
Boron	B	11
Carbon	C	12
Nitrogen	N	14
Oxygen	O	16
Fluorine	F	19
Sodium	Na	23
Magnesium	Mg	24
Aluminium	Al	27
Silicon	Si	28
Phosphorus	P	31
Sulphur	S	32
Chlorine	Cl	35.5
Potassium	K	39
Calcium	Ca	40
Titanium	Ti	48
Vanadium	V	51
Chromium	Cr	52
Manganese	Mn	55
Iron	Fe	56
Nickel	Ni	58.5
Cobalt	Co	59
Copper	Cu	63.6
Zinc	Zn	65
Arsenic	As	75
Selenium	Se	79
Bromine	Br	80
Strontium	Sr	87
Zirconium	Zr	90
Columbium	Cb	94
Molybdenum	Mo	96
Palladium	Pd	106
Silver	Ag	108
Tin	Sn	118
Antimony	Sb	120
Tellurium	Te	125.5
Iodine	I	127
Barium	Ba	137
Tantalum	Ta	183
Tungsten	W	184
Iridium	Ir	193
Platinum	Pt	195
Gold	Au	197
Mercury	Hg	200
Thallium	Tl	204
Lead	Pb	207
Bismuth	Bi	208
Thorium	Th	232
Uranium	U	238

RELATIVE WEIGHTS.

Writing any chemical equation between elements or their compounds, the relative weights concerned in the reaction are obtained directly from using these atomic weights, which are, themselves, of course, only relative. E. g., the slagging of iron in Bessemerizing copper matte:

$$2FeS + 3O_2 + 2SiO_2 = 2(FeO.SiO_2) + 2SO_2$$
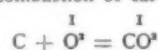$$176 + 96 + 120 = 328 + 128$$
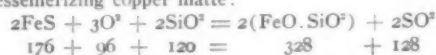
These relative weights may be called kilograms or tons, pounds, ounces or grains; whatever units of weight we may be working in. In most metallurgical work we use kilograms or pounds as the convenient weight units.
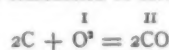
RELATIVE VOLUMES OF GASES.

Where gases are involved, the relative number of molecules of the gaseous substance concerned in the reaction stands for the relative volume of that gas concerned in the reaction. It is usual and convenient to designate these relative volumes by Roman numerals, placed above the formulæ. The following are some simple examples:
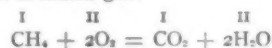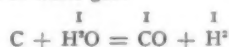
Complete combustion of carbon:

$$\overset{I}{C} + \overset{I}{O_2} = CO_2$$

Incomplete combustion of carbon:

$$2\overset{I}{C} + \overset{II}{O_2} = 2CO$$

Combustion of marsh gas:

$$\overset{I}{CH_4} + \overset{II}{2O_2} = \overset{I}{CO_2} + \overset{II}{2H_2O}$$

Production of water gas:

$$\overset{I}{C} + \overset{I}{H_2O} = CO + H_2$$

In each case above, the volume of a solid or liquid cannot be stated, but the relative volumes of all the gases taking part in a reaction are derived simply from the number of molecules of each gas concerned. These relative volumes may be called so many cubic meters or liters, or cubic feet, or whatever measure is wanted or being used. In most metallurgical calculations it is convenient to use cubic meters or cubic feet.

EXACT WEIGHTS AND EXACT VOLUMES.

If we specify or fix the weights used, as, for instance, so many kilograms of each substance as the numbers representing the relative weights, then we can, by using one constant factor, convert all the relative volumes into the real or absolute volumes corresponding to the weights used. If, for instance, we take the equation of the production of water gas:

$$\overset{I}{C} + \overset{I}{H_2O} = \overset{I}{CO} + H_2$$
$$12 + 18 = 28 + 2$$
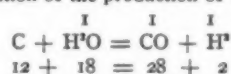
With the relative weights written beneath and the relative volumes above, then if we fix the weights as kilograms, the relative volumes can be converted into actual volumes in cubic meters by multiplying by 22.22. A cubic meter of hydrogen gas (under standard conditions) weighs 0.09 kilogram, and thence 2 kilograms will have a volume of $2 \div 0.09 = 22.22$ cubic meters. But the relative volumes show that the CO and H_2O gas are the same in volume as the hydrogen, and it, therefore, follows that each Roman I stands for 22.22 cubic meters of gas, if the weights underneath are called kilograms. The consideration of these relations is very advantageous, because, by means of this factor (22.22) we pass at once from the weight of a gas to its volume; each molecule or molecular weight of a gas, in kilograms (or, briefly, each kilogram-molecule), represents 22.22 cubic meters of that gas.

The conversion from weight to volume is quite as simple using English measures; and, by a strange coincidence, the same factor can be used as in the metric system. The coincidence alluded to is the fact (which the writer, as far as he can discover, was the first to notice) that there happens to be the same numerical relation between an ounce (av.) and a kilogram, as there is between a cubic foot and a cubic meter; in

short, there are 35.26 ounces (av.) in a kilogram, and 35.31 cubic feet in a cubic meter. The difference is only one-seventh of one per cent, which can be ignored, and we can therefore say that if the relative weights in an equation are called ounces (av.), each molecule of gas in the equation represents 22.22 cubic feet.

Example.—The production of acetylene from calcium carbide:

$$I$$
$$CaC_2 + H_2O = CaO + C_2H_2$$
$$64 + 18 = 56 + 26$$
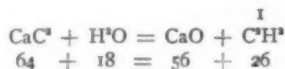
Interpreting by weights, and calling the relative weights ounces, we can call the I molecule of C_2H_2 gas 22.22 cubic feet, so that, theoretically, 64 ounces of pure carbide, acting on 18 ounces of water, produce 56 ounces of lime and 26 ounces of C_2H_2 gas, the volume of which is 22.22 cubic feet.

WEIGHTS AND VOLUMES OF GASES.

The weight of one cubic meter of dry air, under standard conditions (at o° Centigrade and at a pressure of 760 millimeters of mercury), is 1.293 kilograms. The composition of air is:

	By Weight.	By Volume.
Oxygen	3	21
Nitrogen	10	80

or, in percentages,

Oxygen	23.8	20.8
Nitrogen	76.2	79.2

While these may not represent the absolutely accurate average composition of dry air, yet the variations are such that the above simple ratios, 3 to 10 and 21 to 80, are close enough for all practical purposes in metallurgy.

The weight of one cubic foot of dry air is 1.293 ounces (av.).

The weight of one cubic meter of hydrogen gas, at standard conditions, is 0.09 kilogram (1 cubic foot, 0.09 ounces). The formula of hydrogen gas is H_2, is molecular weight 2; and since the densities of all gases are found experimentally to be proportional to their molecular weights, it follows that the density of any gas referred to hydrogen is expressed numerically by one-half its molecular weight. But, the weight of a cubic meter of gas is the weight of a cubic meter of hydrogen multiplied by the density of the gas referred to hydrogen; thus, is obtained the weight of a cubic meter of any gas whose formula is known. Examples follow:

Formula.	Molecular Weight.	Density Referred to Hydrogen.	Weight of 1 Cubic Meter.
Hydrogen ....H_2	2	1	0.09 kilos.
Water vapor ......H_2O	18	9	0.81 "
Nitrogen ....N_2	28	14	1.26 "
Oxygen ....O_2	32	16	1.44 "
Carbon monoxide...CO	28	14	1.26 "
Carbon dioxide ....CO_2	44	22	1.98 "
Marsh gas ....CH_4	16	8	0.72 "

Etc., etc.

In the case of water vapor, a particular explanation is necessary. It cannot exist under standard conditions, but condenses to liquid at 100° C., if under 760 millimeters pressure. It does exist at lower temperatures than 100°, but only under partial pressures of fractions of an atmosphere; thus, at a pressure of of 1-50 atmosphere (when it forms 1-50 of a mixture of gases) it can exist uncondensed at ordinary temperatures (15° C. or 60° F.). The above weight for a cubic meter of water vapor (0.81 kilos. per cubic meter at standard conditions) is, therefore, only a hypothetical value, but it is extremely useful, because it enables us to calculate, by the principles to be explained further on, the weight of a cubic meter of water vapor under any conditions of temperature and pressure at which it is possible for it to exist.

CORRECTIONS FOR TEMPERATURE.

The volumes of all permanent gases increase uniformly for uniform increase of temperature, so that, starting with a given

volume at o° C., it is found that their volume increases 1-273 for every degree Centigrade rise in temperature. Thus, at 273° C., the volume is just double the volume at o°. Stating this fact in another way, we may say that the gas acts as if it would have no volume at − 273° C., and would increase uniformly in volume from this point up to all measurable temperatures, the increment being, for each degree, 1-273 of the volume which the gas has at o° C. A still briefer statement is that the volume of a gas is proportional to its temperature above − 273° C., or to its absolute temperature—the latter being its temperature in C° + 273.

The converse of these principles is, that the density of a gas; that is, the weight of a unit volume, varies inversely as its absolute temperature.

In Fahrenheit degrees, we can say that a gas expands 1-490 (1-273 × 5-9) for every degree rise above 32° C.; or that the volume is proportional to the absolute temperatures, *i. e.*, to the F.° − 32 + 490 (= F.° + 458).

These principles are in constant use in metallurgical calculations. Thus, one kilogram of coal will need 8 cubic meters of air to burn it, at o° and 760 millimeters pressure. What volume will that be at 30° C. and the same pressure? Since 30° C. is 30 × 273 = 303° absolute, the two temperatures will be 273 and 303, and the

$$\text{Volume at } 30° \text{ C.} = \text{volume at } 0° \text{ C.} \times \frac{303}{276}.$$

It is always to be recommended to make such calculations in the above form; that is, to first put down the known volume, and then to multiply it by a fraction, the numerator and denominator of which are the two absolute temperatures. A moment's reflection will show which way the fraction must be written; if the new volume must be greater than the old, the value of the fraction must be greater than unity, the higher temperature must be in the numerator; if the fraction were inverted, we know that the result would be less than the starting volume instead of greater, which would be wrong.

Taking an example in Fahrenheit degrees: What is the volume under standard conditions of 175 cubic feet of gas measured at 90° F. and standard pressure (29.93 inches of mercury)? Since 32° F. is 490° absolute and 90° F. is 548° absolute, and the new volume must be *less* than the starting volume, we have,

$$\text{Volume at } 32° \text{ F.} = 175 \times \frac{490}{548} = 156.5 \text{ cubic feet.}$$

CORRECTIONS FOR PRESSURE.

The principle is that the volumes of a gas are inversely as the pressure upon it, so that doubling the pressure halves the volume, etc. Since the practical problems almost always present the pressures as two numbers, all that is necessary is to multiply the original volume by a fraction whose numerator and denominator are the two pressures concerned, and arranged with the numerator the larger or the smaller of the two numbers, according as to whether the final volume should be greater or less than the starting one. Putting the solution in this manner avoids the primary school method of making a proportion, which is so apt to be expressed upside down, and absolutely avoids error with the minimum exercise of brain power.

Examples: What is the volume of 100 cubic meters of any gas, if the pressure is changed to 700 millimeters?

$$\text{Answer: } 100 \times \frac{760}{700} = 108.6 \text{ cubic meters.}$$

What is the volume at standard pressure of 150 cubic feet of gas measured at 28.50 inches of mercury?

$$\text{Answer: } 150 \times \frac{28.50}{29.93} = 142.8 \text{ cubic feet.}$$

CORRECTIONS FOR TEMPERATURE AND PRESSURE.

These can be both allowed for, by simply correcting first for one, and then for the other. Actually, the simplest statement is to put down the original volume, then to multiply it by one fraction, which corrects for temperature, and again by another fraction correcting for pressure, thinking out carefully for each fraction the proper way of expressing it, i. e., whether it should increase or decrease the volume.

Examples:

What does 100 cubic meters of air at standard conditions become at 50° C. and 780 millimeters pressure?

$$\text{Solution: } 100 \times \frac{50 + 273}{273} \times \frac{760}{780} = 115.3 \text{ cubic meters.}$$

What is the weight of one cubic meter of hydrogen at 1000° C. and 250 millimeters pressure, its weight at standard conditions being 0.09 kilograms?

$$\text{Solution: } 0.09 \times \frac{273}{1000 + 273} \times \frac{250}{760} = 0.00637 \text{ kilograms.}$$

What weight of oxygen is in 1500 cubic feet of dry air at 100° F. and at 28.50 inches of mercury? (Refer to weight of air at standard conditions, and percentage composition.)

$$\text{Solution: } 1.293 \times \frac{3}{13} \times \frac{490}{558} \times \frac{28.50}{29.93} \times 1500 = 374 \text{ ounces.}$$

What is the weight of 50 cubic meters of water vapor at a temperature of 30° C. and a pressure of 31.6 millimeters?

$$\text{Solution: } 0.81 \times \frac{273}{303} \times \frac{31.6}{760} \times 50 = 1.517 \text{ kilograms.}$$

$$\text{or } 50 \times \frac{273}{303} \times \frac{31.6}{760} \times 0.81 = 1.517 \text{ kilograms.}$$

The first expression calculates the weight of a cubic meter of water vapor at the assumed conditions, and multiplies by 50; the second calculates the hypothetical volume of the 50 cubic meters if reduced to standard conditions, and multiplies by the hypothetical weight of a cubic meter at those conditions.

Problems Illustrating Preceding Principles.
Problem 1.

A bituminous coal contains on analysis:

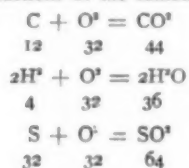|	
Carbon	73.60
Hydrogen	5.30
Nitrogen	1.70
Sulphur	0.75
Oxygen	10.00
Moisture	0.60
Ash	8.05
	100.00

It is powdered and blown into a cement kiln by a blast of air.

Required: 1. The volume of dry air, at 80° F. and 29 inches barometric pressure theoretically required for the perfect combustion of one pound of the coal.

2. The volume of the products of combustion, using no excess of air, at 550° F. and 29 inches barometer, and their percentage composition.

Solution: The reactions of the combustion are:

$$\begin{array}{ccc} C + O_2 = & CO_2 \\ 12 \quad 32 & 44 \end{array}$$

$$\begin{array}{ccc} 2H_2 + O_2 = & 2H_2O \\ 4 \quad 32 & 36 \end{array}$$

$$\begin{array}{ccc} S + O_2 = & SO_2 \\ 32 \quad 32 & 64 \end{array}$$

Requirement (1):

The oxygen required for burning one pound of coal is:

Oxygen for carbon....	= 0.7360 × 32/12	= 1.963	pounds.
Oxygen for hydrogen..	= 0.0530 × 32/4	= 0.424	"
Oxygen for sulphur....	= 0.0075 × 32/32	= 0.0075	"
Total required		2.3945	"
Oxygen in coal		0.1000	"
Oxygen to be supplied		2.2945	"
Nitrogen accompanying		7.6483	"
Air necessary		9.9428	"
		= 159.08	ounces (av.).

Volume of air necessary (standard conditions)

$$= \frac{159.08}{1.293} = 123.03 \text{ cubic feet.}$$

Volume of air necessary at 80° F. and 29 inches barometer =

$$123.03 \times \frac{80 + 458}{490} \times \frac{29.93}{29} = 139.4 \text{ cubic feet. } (1)$$

Requirement (2):

Pounds.

The weight of CO_2 formed is....	0.7360 + 1.963	= 2.729
The weight of H_2O formed is....	0.0530 + 0.424	= 0.477
The weight of moisture is.......		0.060
The weight of SO_2 formed is....	0.0075 + 0.0075	= 0.150

The weight of nitrogen altogether is 7.6483 + 0.0170 = 7.6653 pounds. Converting these weights into ounces, and dividing each by the weight of a cubic foot of each gas in ounces, we have the volume of these theoretical products at standard conditions:

$$\text{Volume } CO_2 = 2.729 \times 16 \div 1.98 =$$
$$43.664 \div 1.98 = 22.05 \text{ cubic feet.}$$

$$\text{Volume } H_2O = 0.537 \times 16 \div 0.81 =$$
$$8.592 \div 0.81 = 10.61 \text{ " \quad "}$$

$$\text{Volume } SO_2 = 0.150 \times 16 \div 2.88 =$$
$$2.400 \div 2.88 = 0.83 \text{ " \quad "}$$

$$\text{Volume } N_2 = 7.665 \times 16 \div 1.26 =$$
$$122.645 \div 1.26 = 97.34 \text{ " \quad "}$$

Total volume at standard conditions.... = 130.83 " "

Volume at 550° F. and 29 inches barometer =

$$130.83 \times \frac{550 + 458}{490} \times \frac{29.93}{29} = 277.8 \text{ " \quad "}$$

The percentage composition by volume follows from the above volume as:

CO_2	16.9	per cent.
H_2O	8.1	"
SO_2	0.6	"
N_2	74.4	"
	100.00	

Problem 2.

Natural gas in the Pittsburg district contains:

Marsh gas	CH_4	60.70	per cent.
Hydrogen	H_2	29.03	"
Ethane	C_2H_6	7.92	"
Olefiant gas	C_2H_4	0.98	"
Oxygen	O_2	0.78	"
Carbonic oxide	CO	0.58	"

Required:

(1) The volume of air necessary to burn it.

(2) The volume of the products of combustion.

Reactions:

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$
$$2H_2 + O_2 = 2H_2O$$
$$2C_2H_6 + 7O_2 = 4CO_2 + 6H_2O$$
$$C_2H_4 + 3O_2 = 2CO_2 + 2H_2O$$
$$2CO + O_2 = 2CO_2$$
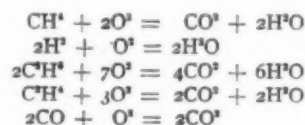
Solution:

Oxygen required for CH_4.. $= 0.6070 \times 2 = 1.2140$ parts.
Oxygen required for H_2... $= 0.2903 \times \frac{1}{2} = 0.1451$ "
Oxygen required for C_2H_6.. $= 0.0792 \times 7/2 = 0.2772$ "
Oxygen required for C_2H_4.. $= 0.0098 \times 3 = 0.0294$ "
Oxygen required for CO... $= 0.0058 \times \frac{1}{2} = 0.0029$ "

$$1.6686 \quad "$$

Deduct oxygen already present ....0.0078 "

Leaves oxygen to be supplied ....1.6608 "

$$1.6608$$
Corresponding to air .... $\dfrac{1.6608}{0.208} = 7.985$ (1)

Volumes of products of combustion:

	CO_2	H_2O	N
From CH_4.......	0.6070	1.2140	
From H_2		0.2903	
From C_2H_6	0.1584	0.2376	
From C_2H_4	0.0196	0.0196	
From CO	0.0058		
From air			6.3242
Total products ..	0.7908	1.7615	6.3242 (2)

The above solution is entirely in relative volumes, which may be all considered cubic feet or cubic meters, and are true for equal conditions of temperature and pressure.

Problem 3.

A Bessemer converter contains 10 metric tons of pig iron of the following composition:

Carbon .... 3.00 per cent.
Manganese .... 0.50 "
Silicon .... 1.50 "
Iron .... 95.00 "

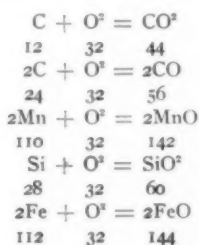On being blown, one-third the carbon burns to CO_2, the rest to CO; 5 per cent of iron is oxidized, and no free oxygen escapes from the converter. Blast is assumed to be dry.

Requirements:

(1) What weight of oxygen is needed during the blow.

(2) How many cubic meters of air, at standard conditions, will be needed.

(3) What will be the average composition of the gases.

Requirements:

$$C + O_2 = CO_2$$
$$12 \quad 32 \quad 44$$
$$2C + O_2 = 2CO$$
$$24 \quad 32 \quad 56$$
$$2Mn + O_2 = 2MnO$$
$$110 \quad 32 \quad 142$$
$$Si + O_2 = SiO_2$$
$$28 \quad 32 \quad 60$$
$$2Fe + O_2 = 2FeO$$
$$112 \quad 32 \quad 144$$

Oxygen needed:

C to CO_2....100 kilos $\times$ 32/12 = 266.7 kilos.
C to CO.....200 " $\times$ 32/24 = 266.7 "
Mn to MnO. 50 " $\times$ 32/110 = 14.5 "
Si to SiO_2..150 " $\times$ 32/28 = 171.4 "
Fe to FeO..500 " $\times$ 32/112 = 285.6 "

Total .... 1004.9 " (1)
Nitrogen accompanying this .... = 3349.7 "

Air needed .... 4354.6 "

$$4354.6$$
Volume of air ...... $= \dfrac{4354.6}{1.293} = 3367.8$ cubic meters. (2)

Volume of products of combustion:

$$366.7$$
$$CO_2 = 100 + 266.7 = 366.7 \text{ kilos} = \dfrac{366.7}{1.98} = 185.2 \text{ cu. m.}$$

$$466.7$$
$$CO = 200 + 266.7 = 466.7 \text{ kilos} = \dfrac{466.7}{1.26} = 370.4 \text{ cu. m.}$$

$$3349.7$$
$$N = \dfrac{3349.7}{1.26} = 2657.9 \quad ''$$

Total volume .... 3213.5 "
Percentage composition by volume:
CO_2 .... 5.8 per cent.
CO .... 11.5 "
N .... 82.7 "

[The next instalment of the "Metallurgical Calculations" will deal with the thermochemistry of metallurgical processes.]

A System of Classification for an Electrochemical Bibliography.

BY ADOLPH L. VOEGE.

If a scientific investigation is undertaken in a university to-day, the experimenter is advised to devote two-thirds of his time to the literature of his subject, much of which must be spent in locating that literature. The work is completed, published, and the experimenter later discovers an earlier article unknown to him which offers suggestions that would have advanced his work much beyond where he left it. A manufacturer sees a by-product wasted or making but small returns. He wishes to put it to better use, to know in what trades its elements or their compounds are employed, and to learn the processes of their manufacture; but no thorough method of doing this now exists. An inventor must know completely the work already done in his field or his thought and time are largely wasted and misdirected. He hazards that to-day. Who does not fail to appreciate all of the numerous applications of a given principle of operation? Who does not recognize the difficulty of tracing the complete published work of any man?

These are needs at present, but it is conceivable that they could be overcome by a living index, properly manipulated, of all of the literature of a subject.

To keep pace with any branch of science, no book system is applicable, even assuming it to be otherwise perfect; in a half-dozen years the searcher is confronted with as many volumes, their indices and references. A book is old and incomplete when put on the market. It is inexpansible-bound.

Every specialty is growing. It requires independent indexing, where the title of each of its articles stands by itself. This means, for sufficient elasticity, nothing less than a card index.

The two main demands of an index are arrangements by authors and subjects. The author index can be alphabetical; but its use presupposes familiarity with an author, and generally with his work, a knowledge that most investigators do not have, and which greatly limits its value. It is more often of importance to learn all that has been done in a certain line, of its mere existence, when the experimenter's name is not known, and is of little interest. This makes the great demand for the second classification, the subject index. A system is required for this where articles on common subject matter are not liable to be separated by the use of synonomous terms, the estranging tendencies of the daily press, or the language in which the articles are written, but where they will be grouped by inherent characteristics and principles, and a list of references be secured, complete at a single point.

This system for economical operation must be such that the manipulation of it by unskilled labor is feasible.

The first requirements are fulfilled by the relative subject system, in which the subjects are grouped and classed from consideration of related interests.

The requirements of speed and cheapness are fulfilled by

subdividing the classes into approximately equal groups and assigning to each subject of each group a unique symbol. These symobls might be characters, letters or numbers. Characters in general lack the essential of simple consecutiveness. Letters fail, in groups, through slow appeal to the eye, through lack of rhythm (especially in consonant groupings) to the ear, and through the labor of tracing their correct consecutive order in their comparatively large body, the alphabet, to the memory. Arabic numbers overcome these objections, and applied as decimals, their base, 10, reduces consecutiveness to the most well-known form.

The relative subject decimal system, therefore, has been found superior to others, and it is proposed to employ it for the bibliography of electrochemistry, which is being undertaken. This system will be applied to the formation of a printed scheme wherein each class, branch and sub-branch of the science after much study, is carefully given a place among those most closely related to, or affected by it. A number is then assigned to each branch which identifies it always. This system possesses boundless expansibility, for we have but to add a decimal-place to any sub-group to obtain ten new subject locations under that sub-group. The first consideration in prefixing these numbers will be conformity with existing bibliographical work classification. Then, with the assistance of specialists, more detailed division will be secured. These theoretical groupings will be made to yield to positions of greatest usefulness through testing the provisional system with several thousand titles collected from varied old and recent sources. The final grouping arrived at will be that used for the bibliography. It will be arranged into a printed scheme and the numbers that have then been assigned must never be altered.

The system of Melvil Dewey, librarian of the New York State Library, as elaborated by the Institute de Bibliographie, of Brussels, and the Institute de Bibliographie, of Paris, is based on the above principles, and will form the foundation of the electrochemical classification. It has arranged human knowledge into nine great classes: Philosophy, Religion, Sociology, Philology, Science pure, Science applied, Art, Literature and History, utilizing a tenth great class for general topics applying to all of these, such as societies, schools, periodicals and so forth. To these ten classes one thousand main divisions have been given; those for pure science ranging through 500, and for applied science through 600. Further, pure science is grouped into mathematics, astronomy, physics, chemistry with mineralogy, geology, paleontology, biology, botany and zoology, with another division, reserved for topics general to all of pure science. Physics then extends from 530 through 539, having sections for mechanics, hydraulics, pneumatics, acoustics, optics, thermics, electricity, magnetism and the ever-present section for generalities. Electricity thus becomes 537. By adding one decimal figure to this ten new subdivisions are obtained. These are given to theories, statics, galvanic, atmospheric and dynamic electricities, to electrodynamics, applications, tables and problems. Galvanic electricity would be located then by 537.3, and may be sub-divided into propagation, calorific phenomena, electrolysis, electrolytic polarization, cells, various current actions with the other divisions still held vacant to provide for the growth of the science. These can be again sub-divided, and later these sub-divisions receive further expansion. The expansibility of the system is unlimited.

Electrochemistry must enter the divisions of several groups of physics, 530, and of chemistry, 540; of applied science chiefly under electrical engineering, 621.3; chemical technology of chemicals, 661; and metallurgy, 669. Two criticisms of this separation will be made. One will be that electrochemistry should be, as a science, concise; a unit. The second, that many subjects have not been correctly located, will be heard from the specialist who tends to the belief that many subjects are of most special interest to his own branch. They may be

answered by extending a borrowed simile: "A railroad must choose the most direct course to serve the most people, and its running schedule cannot be intelligently criticised by the patrons of any one of its sections. Whether 9:45 or 9:46 is the time of train departure for any station should be of small moment; that it carries one to his destination rapidly should suffice." The assignment of train departures is left to the despatcher's bureau, represented by the bibliographer, who knows the different positions of moving traffic and cross-roads, and seeing all sides of a relationship, prevents collisions.

To illustrate the arrangement of the headings of the final scheme, the following page from the provisional scheme for metallurgy, 669, is presented:

669.5	Zinc.	
.51	Origin. Properties. General processes. Statistics.	
.51	Minerals.	
.521	Zinc sulphide. Blende.	
.522	Zinc carbonate. Calamine, etc.	
.523	Zinc silicate. Willemite, etc.	
.524	Zinc oxide. Franklinite.	
.525	Zinc aluminate.	
.53	Extraction by dry methods.	
.531	Silesian process. Calcination.	
.532	Belgian process.	
.533	English process. Distillation from crucibles.	
.534	Combined processes.	
.54	Extraction by electricity.	
.541	Extraction by electric separation and distillation.	
	Processes of Siemens and Halske, Cowles, etc.	
.542	Extraction by electrolysis of the chloride. (fused).	
	Process of Lorenz.	
.543	Extraction with soluble anodes.	
	Processes of Luckow, Hermann, Friedenshutte, etc.	
.544	Extraction by electrolysis of sulphate solutions.	
	Processes of Lestrange, Linderman, etc.	
.545	Extraction by electrolysis of chloride solutions.	
	Processes of Heinzerling, Hopfner, Forster, etc.	
.546	Extraction by electrolysis of ammoniacal or alkaline solutions.	
	Processes of Burghardt, Mond, Diffenbach, etc.	
.55	Working of zinc.	
.56	Refining of zinc.	

Treating the index in the spirit of the satisfied commutor suggested above, an attempt will be made to show, not how it does things, but rather what it will do. It has developed into three distinct parts; a printed alphabetical list of subjects and synonyms, with the assigned decimal of each affixed; a printed tabulated scheme with the subjects relatively grouped by their prefixed decimals, and a drawer or more of arranged cards of printed references. These are the tools.

It is desired to find what has been done, and where, and by whom, on damage to street mains by stray electric currents. Two methods of obtaining the answer offer. Conduit electrolysis can be looked up in the alphabetical index and its number found to be 621.315.25; then the cards of this number can be sought in the tray aided by guide-cards; and following those of 621.315 and preceding those of 621.316, grouped together, all of the cards of 621.315.25 are found. On each is a printed reference to one article that has appeared on our subject, consisting of the decimal of the subject in one corner, the author's name in the opposite one, and below, the year of publication of the article, with its title, and its English

translation, the periodical, volume and page-limits, mention of illustrations, etc., together with a short explanatory note and a group of decimals, serving in concise manner as a digest of its contents. Had the searcher looked up "corrosion" or "electrolysis" or other leading word in the alphabetical index, under all of these would have been found a sub-head referring conclusively to the subject and possessing the same number as "conduit electrolysis" already determined. In the second method, the related subject scheme would have been used. Under the great head 621.3 "industrial electricity" would have been found a group, 621.31 "production and transformation of electric energy," with a sub-group 621.315 "conductors," of which one division is 621.315.2 "underground conductors," and here the subject would have been located under the sub-division 621.315.25, "electrolysis due to underground conductors."

This illustration is an electrochemical subject, yet it is isolated among the problems of linesman's work, because it means more to the linesman than to the electrochemist. It has been assigned the number of greatest utility.

However, there is a conviction of great flexibility which makes the adaptability of the system to special needs limitless. It is that of expressing relationships. As an instance of its use, an anatomist has interest in X-rays, still all X-ray work cannot be relegated to anatomy; however, a card can be numbered 611:537.531 where the numbers for anatomy and X-rays are united by the colon, the symbol for relationship. These cards, being of a general nature, would appear in the card-drawer after those of 611, and before those of 611.1. By reversing the position of the numbers with respect to the colon, we form the card for the X-ray group, 537.531:611, meaning X-rays applied in anatomy.

Again, were the problem to find what work had been done in preparing "membranes appropriate for osmotic pressure determinations," "membranes" or "diaphragms" or "dialyzing apparatus" will be found in the alphabetical index numbered or having a branch numbered 532.720.71. Turning to the card-drawers, the guide-cards, taller than the reference cards, lead the searcher by the numbers printed on them, in a few seconds to the cards of this number with their references to what has been done on the subject. Had the scheme tables been used, under 530 "physics" and its group 532 "liquids" would have been found a division, 532.7 "osmose," with a sub-division, 532.72 "osmotic pressure": and under the general head of this sub-division, 532.720 would be found 532.720.7 "apparatus" with a section 532.720.71 assigned to "diaphragms and membranes."

As a final illustration of the application of the system, it is desired to determine "the electrolytic sodium manufacturers of England" (so far as their plants have received mention in the literature). The numbers for "electrolytic sodium" and for "England" are determined. Sought through the scheme, under 660, "chemical technology" is a main group, 661 "manufacture of chemicals" with a great sub-group, 661.3 "manufacture of alkali" having a division, 661.32 "manufacture of sodium salts" with a sub-division, 661.323 "sodium," one branch of which is 661.323.2, "preparation of sodium by electrolysis." Following up the geographical portion of the scheme, distinguished by the parenthesis ( ), we find (4) "Europe," (42) "England." Turning to the card-drawer containing the cards for 661.323.2, electrolytic manufacture of sodium, following the relationship, colon, cards for this number are the geographical, or parenthesis, cards, and under these 661.323.2 (42) are those on "English plants."

By the use of type of different heights and heaviness of face, for the several decimal groups, the formidable appearance of such numbers is lessened. The last illustration would appear thus: 661.323.2 (42).

As illustrative of the electrochemical literature easily overlooked, among the one thousand electrochemical patents of Switzerland, important ones have been found in such unsuggestive sections as the classes devoted to varnish manufacture, liquor and beer ageing, canning industries, and glass smelting. In over 50 per cent of the classes electrochemical patents exist.

The application of this system is to be undertaken as a branch of the Concilium Bibliographicum of Zurich, Switzerland. A paper explaining the scope of the work this institute hopes to accomplish, and the spirit in which it is undertaken and the general plan to be followed by the enterprise, was presented at the April meeting of the American Electrochemical Society, and published nearly in full on page 313 of the August issue, 1904, of this journal.

Notes on Electrochemistry and Electrometallurgy in Great Britain.

(From Our Special Correspondent.)

STANDARDIZATION IN RELATION TO ELECTROCHEMISTRY.

At first sight there does not seem to be much room for standardization. Electric furnaces are not only numerous, but the application of a single maker's type of furnace frequently requires modification for various products, and one can only assume that none of the sub-committees of the British Engineering Standards Committee will give much attention to the subject. An interim report, however, of the sub-committee on generators, motors and transformers, issued last summer, is not without interest. Unfortunately, a great deal of electrochemical plant does not readily lend itself to standardization. The makers of small dynamos for low voltages and heavy currents are not numerous, and while each of such firms has doubtless its own standard sizes, these undoubtedly differ between firm and firm. When, however, we consider dynamos of higher voltages, the value of the work of this sub-committee to this specific industry becomes at once apparent. Those who propose to run several electrolyzing tanks in series across terminals connected to low-pressure distributing mains, should bear in mind that the standard low pressures recommended are 110, 220, 440 and 500 volts.

In one manner, an indirect one, it is true, the recommendations as to motors should certainly be borne in mind by the manufacturers of special low-voltage generators. It may be suggested that their particular shop standards of design should be synchronized with the speeds laid down for direct and alternating-current motors. It is only in very extensive works that the putting down of a special prime mover, steam or electric, will really pay. The average isolated small plant which one sees, in works where electrochemical work is carried on with its gas engines, countershafting and belting, is an anachronism in the days of cheap electric power distribution in nearly every municipality in Great Britain. The electric motor directly coupled to the shaft of the special generator is surely preferable to antiquated devices for wasting power in the form of friction. It seems highly probable that the interest and depreciation on the motor would be met by the saving of transmission losses. Electric current at 2d per unit is undoubtedly superior to gas at 2s 6d per 1000 cubic feet, and the items of wear and tear, lubrication and cooling water for the gas engine would disappear from the works accounts.

The recommendations of this sub-committee, which are too long for quotation, may be obtained by American firms who hope to supply such apparatus to Great Britain by application to the Engineering Standards Committee at 28 Victoria Street, London, W. C. Another feature of the report in question lies in the striking differentiation made between generators and motors which work under a fluctuating load, and those which work under a steady load. An electrochemist has no use for an armature which becomes unduly heated

when running at its rated load. The sub-committee is investigating the matter by tests at the National Physical Laboratory at Teddington, and at the works of certain makers, with a view to formulating a temperature limit.

FARADAY SOCIETY TRANSACTIONS.

The Faraday Society has just issued Vol. I, part I, of the Transactions, which, from now on, will be published quarterly. The first number contains papers by H. J. S. Sand, B. Pool, H. D. Law and F. M. Perkin, L. Kahlenberg, F. J. Brislee, A. Minet, F. M. Perkin and W. C. Prebble, and F. Gelstharp, all of which were abstracted in ELECTROCHEMICAL AND METALLURGICAL INDUSTRY. There is also a note by L. Gaster on the use and treatment of siloxicon.

METALLURGICAL PAPERS OF THE MONTH.

The Institute of Mining and Metallurgy had at their meeting on January 19, four papers down for reading. One, by Mr. H. E. West, dealing with "Early Dry-Crushing Plants in Western Australia and the Introduction of the Filter Press," was historical, if that adjective can be applied to events happening within the last decade. Among the reasons that led to the adoption of the dry-crushing process in Kalgoorlie, or at least on the Hannan's Brownhill mine, was probably first and foremost the scarcity of water, which cost 10s. per 1000 gallons at the government wells in 1896, for salt water. Fresh water in the previous year had fallen from 6d. to 2d. per gallon at Coolgardie, where government condensers were installed; but the conditions at Kalgoorlie were not so accommodating, and the first mill was erected long before any water was met with in the Brownhill Extended. A dry-crushing process, therefore, on the face of it, was presumed to require less water than wet-crushing, and this premise, whether correct or otherwise, was decidedly a factor of selection. The main advantages of this principle of reduction proved to be, however, in actual practice, not so much conservation of water as a more efficient state of the crushed pulp for gold extraction, in a condition amenable to direct cyaniding after the elimination of a certain percentage of fines; also, an efficient air separation of the fines in a dry state, for independent treatment; which ultimately resolved itself into filter pressing, a process also adopted in wet crushing and thus eventually becoming common to both systems. Filter pressing, moreover, gave a considerably higher extraction than percolation, it being safe to assume 90 per cent to 92 per cent of the gold contents, and of silver there was nothing to speak of.

The second paper, by Mr. Sydney Fawns, consisted of some "Notes on the Mount Bisthoff Tin Mine, Tasmania." According to the author cheapness and efficiency of operation have not yet been fully attained, for the cost of firewood is very high, and as all the boilers are old, and more or less out of repair, the horse-power must cost anything between 4d. and 6d. per unit; this can be greatly reduced by the use of electric power. There is a splendid supply of water-power below the dressing sheds near the mine running to waste, and, with a proper installation, the power would not cost more than a fraction of 1d. per unit. Hauling by electricity, instead of by the locomotive at present in use, would have the additional advantage that the motor could be worked in the tunnel underneath the present workings. The cost of mining crushing and dressing a ton of stanniferous material containing 1.322 per cent of tin amounts to 6s.7.933d. The company owns its own smelting works, in which the furnaces used are of the reverberatory type. The charge for each furnace is 50 cwt. of ore and 10 cwt. of small coal. Eight hours are allowed for complete reduction. The metal is tapped into a float or brick-lined vessel, the slag on partial cooling being skimmed off and the metal refined in a large kettle by sinking billets of green wood under the surface, the steam arising from the wood releasing the dross, which is then skimmed off the surface. The metal, when refined,

assays 99.80 per cent, and is shipped to England in the form of ingots weighing 75 pounds each. The slags vary in richness according to the ore treated and the working of the furnace, the average assay value of the slag being 5.3 per cent. The slags are broken up and mixed with small coal and lime and resmelted; the resulting metal being impure from the presence of a large quantity of iron, this metal is again resmelted with the next charge of ore.

Mr. G. A. Stonier, formerly chief inspector of mines in India, read the third paper, which dealt with "Mica Mining in Nellore (Southern India)." The method of preparation for market is crude enough in all conscience. The mica is carried from the mines to the dressing sheds in saucer-shaped baskets 1 foot 6 inches in diameter and 6 inches deep, made from the stalks of the date palm leaf or from jungle creepers at a cost of 1d. each. The headman selects and personally splits up the good plates with hoop iron or a cheap knife with 3-inch blade and 4-inch handle (purchased in the local bazaar for 2d. each) to obtain flat pieces free from flaws and cracks, not more than ⅛-inch in thickness and without cross-graining. They are passed on to women and children, who, with a knife and sheet tin or zinc templets, mark on them as large a rectangle as possible. The cutting along these ruled lines is done by men with ordinary European garden-shears, one end being firmly embedded in a block of wood buried in the ground, so that the cutting edge lies in a vertical plain. The poorer qualities of mica are treated in the same way, and the rectangles are tied into bundles according to the different qualities (1) clean; (2) stained; (3) spotted, and where possible according to sizes which do not differ by more than an inch in length. Compared with the Koderma mines in Bengal, which, in 1902, yielded 923 tons of mica, employing 7,363 persons, the Nellore mines are small, their output in 1902 being only 143 tons, in the mining of which 2097 persons were employed.

The last paper, by Mr. E. H. Garthwaite, merely described a shaft-signalling device of a mechanical nature.

THE FARADAY MEETING.

For the meeting on January 30th three papers were announced, but only two were circulated to the members. Mr. John G. A. Rhodin's paper on "Mass Analyses of Muntz's Metal by Electrolysis" was first read. It was a pity that Mr. Rhodin was manifestly out of health, and no one will regret more keenly than the able author that he was not able to do full justice to his interesting paper. To begin with, the paper was read practically in its entirety, so that the discussion was not started until very late in the evening. The discussion was somewhat disconnected, and degenerated into a species of cross-examination, the editing of which will not be an easy task for Mr. Spiers.

Dr. Beckett Denison's paper on "The Equilibrium between Sodium and Magnesium Sulphates" was taken as read, and members requested to send their communications thereon to the *Proceedings.* Lastly, Mr. E. Kilburn Scott, in place of reading the paper, announced, said a few words on furnace linings, and the meeting adjourned.

THE DURATION OF BRITISH COAL SUPPLIES.

Twice within the memory of some of those who are not yet fifty years of age, the British public has suffered from scares respecting an immediate exhaustion of coal supplies. Two Royal Commissions have sat thereon, the second being mainly necessitated by the fact that the predictions of the first commission as to the future annual output were speedily falsified. A large electro-chemical industry can never flourish in England, because of our deficiencies of water-power. Probably there are no water-falls in the United Kingdom of 100 hp. that have not already been annexed by one industry or another. On that account a supply of cheap fuel is of even greater importance to those interested in British electro-

chemical or electrometallurgical processes than it is, say, to the Bradford woolen industry. The report of the last commission is of a generally reassuring nature, the commissioners estimating the coal available within 4000 feet of the surface as amounting to about 101,000,000,000 tons. Of substitutes for coal, nature, which has so plentifully endowed us with steam coal, has not provided us with petroleum or natural gas. On that account considerable space is given in the report to possible economies in the getting and consuming of coal. About 25 per cent to 30 per cent of the present annual internal consumption of 168,000,000 tons should be saved by judicious economies. In many cases the internal combustion engine is recommended for use. Also, it is recognized, that many seams which cannot now be worked at a profit, will in the future be rendered profitable by washing, sorting, coking, briquetting the coal, or converting it into gas. This should all tend to limit the cost of fuel for the next generation or so.

EXPIRING PATENTS.

The following British electrochemical patents of 1897 expire in 1905:

4,757   T. L. Wilson, Electrical Reduction Aluminium.
4,860   H. Howard, Electrical Heating and Welding.
13,124   H. Howard, Electrical Heating and Welding.
13,125   H. Howard, Carbon Holders and Screens for Electroheating and weldings.

19,775   A. Breuer, Diaphragms for Electrolytic Decomposing Apparatus.

So far as the writer is aware their expiration is not likely to greatly influence electrochemical development over here.

MARKET QUOTATIONS.

Chemicals have again been steady, no important changes have taken place, except in regard to shellac, which has now fallen to 156s. per cwt., a fall during the months of 44s.

Fine Para rubber is still at 5s. 3d. per pound, and guttapercha unchanged at 8s. od. per pound. Ceylon rubber has not been so prominent during the month. Some Ceylon planters of my acquaintance expect the price to recede to about 4s. od. per pound in the course of eighteen months or so.

Platinum is unchanged at 81s. 6d. per ounce. The only hope for a fall in the price lies in the ending of the Russo-Japanese war, which will permit of the development of other platinum mines. Copper has remained fairly steady, weakening slightly towards the end of the month. Cleveland pig iron has fallen to 48s. od. Block tin is still falling, being now quoted at £131 to £132 per ton, as against £134 to £135 at the beginning of the month. Ingot and sheet lead have each fallen 5s. od. per ton, being now quoted at £12.17.6 and £14.2.6, respectively.

London, February 4.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

BY GEORGE P. SCHOLL, PH. D.

ELECTRIC FURNACES AND FURNACE PRODUCTS.

Process of Separating Metals from their Ores.—J. M. A Gerard, Paris, France. Patent 780,651, Jan. 24, 1905. Application filed Jan. 27, 1902.

The process relates especially to the production of steel directly from the ore, and is carried out in the furnace Fig. 1.
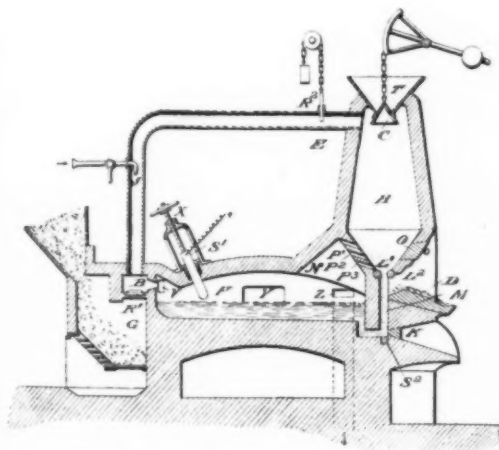

FIG. 1.—ELECTRIC STEEL FURNACE.

The structure comprises a shaft furnace as well as a reverberatory, and in the former the ores are reduced to iron sponge, while in the latter the sponge, which has been melted in the lower part of the reduction furnace, is refined. A gas producer is also a part of the apparatus. The iron ore, mixed with a suitable quantity of reducing agent and flux, if the latter is required, is charged into the hopper T, from which it passes into the furnace H by means of a bell C. At the place

where the furnace bosh joins the hearth, a pair of electrodes L' L² are located, which serve the purpose of melting the reduced material and the gangue. A discharge channel D, located at the top of the conduit M serves for drawing off the slag. The molten metal falls into this conduit M, which connects the reducing part of the apparatus with the reverberatory part. An opening O in the bosh of the apparatus serves for the discharge of the furnace at the end of the operation. The reverberatory part F is provided with an opening V for the admission of air for burning the producer gas, and an opening Z which leads to the regenerative chambers, not shown. In addition the part F is provided with the positive electrode S' of an electric circuit, which can be regulated by the handwheel X. The negative electrode of that circuit is located on the bottom of the conduit M. The producer G communicates by means of a register R', which can be closed if the communication is to be shut off, and a passage B with the reverberatory furnace. A chamber N in the top of the furnace communicates with the reducing furnace H through openings P' P² P³. A draw-off pipe E for the gases, which can also be closed if desired by means of the register R², leads from the upper part of the furnace to the passage B. A steam injector J permits regulation of the gas current. The process to be carried out in the furnace, as described, for the production of steel is stated to take place in the following manner: The ore mixed with carbonaceous and fluxing materials is initially heated in the reducing furnace by the hot gases from the producer. When the proper temperature for reaching is reached, these gases are shut off and a circulation of gases from the reduction furnace begins. The gases are drawn off through pipe E, aided in their circulation by the injector J, and enter the refining furnace F, where they heat and keep molten the material which has accumulated in the furnace. They then pass into the reducing furnace to heat the charge. This cycle of operations is stated to continue until the ore is reduced to sponge, which, as the ore is reduced, passes between the electrodes L' L² and is there melted by an electric

current which should be of low voltage and high amperage. The slag passes off by the passage *D*, while the fluid metal sinks down in the conduit *M* and enters the reverberatory furnace *F*. When a suitable quantity of material has accumulated in the latter, the operation in the reducing furnace is stopped and the gases from the top as well as the steam injector are cut off. The refining operations now begin under the action of the electric current and previously heated air which is introduced through passage *V*. The positive electrode *S'* is brought into contact with the molten metal by regulating the extent to which it is introduced into the mass. A current of high voltage and low amperage is passed into the bath, which current is stated to cause an ebullition and projection of globules of metal above the surface of the bath, the effect of which is said to increase the surface presented to the oxidizing gases in the furnace and to stir the metal. The current necessary for this purpose is stated to be more or less variable, depending upon the mass to be treated and the number of electrodes employed. From 75 volts to at least double that amount are stated to give satisfactory results, while a current density of about ten amperes per sq. cm. cross-section of electrode is generally sufficient. The gaseous products during the period of refining are taken off through opening *Z*.

Electric Furnace.—D. B. S. Galbraith, Aukland, New Zealand. Patent 779,844. Jan. 10, 1905. Application filed Oct. 27, 1903.

The furnace is mainly intended for the treatment of iron sands, presumably such as occur in New Zealand. The furnace consists essentially of a rectangular structure, with a rather deep rectangular hearth for the reception of the liquid metal and the slag. It is, however, intended to break up the material of the charge, while it passes through the middle or fusing zone of the furnace, into a series of thin streams. For this purpose V-shaped troughs with perforated bottoms are arranged across the furnace, in a direction parallel to its longer axis. Below them is placed a row of non-conducting bars of crescent shape, upon which the material falls in its descent. Carbon conductors rest upon the ends and are partly embedded in these non-conducting bars. The material resting upon the latter thus completes the circuit between the electrodes, and is, in consequence, heated to redness. In this manner the particles of the charge were subjected to repeated fusion, inasmuch as several rows of these non-conductors or intercepters are placed in staggered fashion below each other, on which the material treated in the uppermost row falls in its descent. During this time, a current of reducing gas from an independent source acts on the material. The intercepters are made of beauxite or any other suitable refractory material and may be made to rotate.

ELECTROLYTIC PRODUCTION OF METALS AND COMPOUNDS.

Electrode.—E. F. Price, Niagara Falls, assignor to Union Carbide Co. Patent 779,733. Jan. 10, 1905. Application filed June 28, 1904.

The patent relates to electrodes composed mainly of calcium carbide, such as are used in J. J. Griffin's process of producing chemical compounds by electrolyzing solutions with a carbide electrode. This process was described in ELECTROCHEMICAL INDUSTRY, Vol. II, page 206. As it is difficult, however, to obtain pieces of calcium carbide of sufficient size, regular shape and uniform composition, to serve as practical electrodes, and moreover the reaction between the carbide and the electrolyte is apt to disintegrate and destroy the electrodes, the present invention provides for manufacturing a composite electrode, made of calcium carbide and a binder. The preferred binding agent is a coked hydrocarbon or a carbonaceous substance, such as bituminous coal. In order to produce the electrodes, calcium carbide is crushed and mixed with the binder, *f. i.* 5 to 25 per cent by weight, of pulverized bituminous coal and a small amount of water free tar or pitch. The

mixture is then molded into the desired form by means of a press or by forcing it through a die and cutting the resulting mass into the desired length. The pieces thus produced are baked at a temperature sufficiently high to decompose the hydrocarbons and to drive off the volatile matter, thus converting the bituminous material into coke. The coke not only binds the mass well together, but it also increases the conductivity, and is stated to be especially useful when the electrodes are to be used in aqueous solutions, as it retards the action of the water on the carbide, although its porosity permits the water to finally react on all the carbide. The porosity of the electrode may still further be increased, by saturating it with a liquid hydrocarbon or carbohydrate and again baking it and thereby depositing more carbon in the pores.

Electrolysis.—G. Rambaldini, Miniera di Bocchegiano, Italy. Patent 779,735. Jan. 10, 1905. Application filed Jan. 28, 1902.

The inventor proposes to conduct electrolysis in a vessel divided into two compartments by a non-porous, non-conducting partition, each compartment being filled with a different liquid. A horizontally arranged flat electrode is located in each compartment close to the upper edge of the liquid. The partition, however, does not reach to the upper edge of the containing vessel, and space is thus provided for a third solution of lesser specific gravity, which is arranged in a layer above two lower solutions. It is stated to be generally advantageous to employ as third liquid a dilute solution of the acid corresponding to the salt which is to be electrolyzed. Thus for the Siemens process for the electrolytic precipitation of copper from solutions containing sulphate of copper, the third liquid may be constituted by a dilute solution of sulphuric acid, while for the Hoepfner process, where the copper is present as cuprous chloride, the third liquid may be a dilute solution of hydrochloric acid. An apparatus for the electrolysis of waters of cementation is described as an example of the practical application of the method. It is a long vessel, separated by a number of partitions, as described above, into a series of compartments. Those of uneven number are filled with the waters of cementation, which are a mixture of sulphate of copper with other metallic sulphates, among which the sulphates of iron generally greatly predominate. The ferric sulphate has first been converted into ferrous sulphate and the waters have been concentrated as much as is possible with regard to the normal temperature for their treatment. The cells of even number are filled with a solution of sulphate of copper of 20 to 25° Bé. Above these solutions, water acidulated with sulphuric acid to a density of 10 to 15° Bé is carefully poured almost up to the edge of the containing vessel, in such a manner as to establish a sharp dividing line between the two layers. Means are provided for circulating the liquids in the compartments, while maintaining the upper liquid at rest. Some centimeters below the upper surface of the liquids in the compartments horizontally arranged sheets of copper or copper-covered materials are located, which serve as electrodes, suspended from above by electrical conductors, which should be insulated from the liquid. The electrode dropping into the water of cementation is connected to the positive pole and that dipping into the sulphate of copper with the negative pole.

Method of Treating Alkaline Solutions of Chromate of Soda.—W. T. Gibbs, Buckingham, Canada. Patent 779,705. Jan. 10, 1905. Application filed Feb. 10, 1904.

The process is intended especially for the production of bichromate of soda from the leach liquor, which is produced in the present method of manufacturing bichromate of soda. The commercial method of producing the leach liquor, and which is preferably used in this connection, consists in heating a mixture of chrome ore, lime and carbonate of soda until practically all the oxide of chromium is converted into chromic acid, which combines with the soda, forming sodium chromate. The roasted mass is then removed from the furnace, cooled and leached with water, when the chromate of soda and the excess

of carbonate of soda present go into solution, while the lime and the gangue are left as an insoluble residue. The fresh liquor will contain caustic soda, some of which is, however, gradually converted into carbonate by exposure to the atmosphere. This alkaline solution of chromate of soda is, according to the proposed process, first subjected to a treatment with carbonic acid gas, preferably by pumping the gas through a column of the liquid as in the manufacture of sodium bicarbonate. The alkali present is thus converted into sodium bicarbonate and precipitated. The solution is then introduced into an apparatus divided into two compartments by a porous diaphragm. The anode compartment contains an anode of platinum or of another suitable material, while the cathode is formed by metallic iron or any other material not acted upon by alkali. During electrolysis sodium bicarbonate is formed in the anode compartment, while caustic alkali is set free on the cathode side. The cathode liquor from the cell is similar to the original leach liquor, but contains more free alkali and less sodium chromate. This liquor is concentrated by evaporation to bring up the chromate in solution to such strength that bicarbonate of soda is insoluble in the liquor, and is then treated with carbonic acid gas in the same manner as above so as to precipitate the alkali as sodium bicarbonate. The neutral solution of sodium chromate thus obtained returns to the process, preferably mixed with leach liquor prepared as above. The cathode liquors thus successively formed are successively treated with carbonic acid gas and returned to the cell with successive portions of the leach liquor. The anode liquors from the cell contain nothing but bichromate of soda, and are removed when they are concentrated enough and merely evaporated to the point at which they solidify on cooling, thus giving a cake of solid bichromate of soda.

Electrochemical Separation of Metals.—W. Mc. A. Johnson, Hartford, Conn. Patent 780,191, Jan. 17, 1905. Application filed June 23, 1902.

The process relates principally to the electrolytic refining of iron, which is carried out in a rectangular tank provided with a series of anodes and cathodes arranged in parallel. The electrodes do not reach entirely to the bottom of the apparatus, a considerable space being provided underneath them for the reception of the sludge formed during electrolysis. Slabs of slate are interposed between the lower ends of the electrodes, so as to prevent the formation of trees at those parts. The anodes consist of the iron which is to be refined, while the cathodes are thin sheets of iron or steel formed by rolling or by previous electrodeposition. The electrolyte may consist of a solution of ferrous ammonium chloride, slightly acidified if desired with acetic or some other weak organic acid, while a solution of ferrous ammonium sulphate may be used when the presence of a small percentage of sulphur in the deposit is permissible. The process of deposition is stated to be economically conducted at a temperature of 60° C, which accelerates the action. A current density of 10 to 20 amperes per square foot is desirable, while the voltage between the electrodes may be about 1½ volts. During the process of deposition, when the electrolyte is found to contain too large a percentage of copper, etc., either derived from the anodes or from an impure electrolyte, it is run into a cementation tank containing scrap-iron for the purpose of removing the copper. The electrolyte is thus kept in a condition which will assume the deposition of metal of the desired degree of purity, and to insure the deposition taking place in a uniform manner it is desirable to run the electrolyte continuously through the cementation tanks. It is stated that in this way the phosphorus, arsenic, antimony and carbon combined in the iron being refined will fall down as sludge, mostly as phosphides, arsenides, etc., of iron. Any precious metals will also be found in the sludge, while the manganese, nickel or cobalt present in the iron will be deposited with the iron as an alloy upon the cathode.

Method of Coating Metals.—Hugh Rodman, Cleveland. Patent 781,230, Jan. 31. 1905. Application filed Dec. 3, 1904.

The invention relates to a method of securing upon a metal, such as iron or copper, an adherent coating of a fusible metal, such a lead, tin or zinc. The coating is effected in a bath of the fusible metal in which a suitable proportion of a highly electropositive metal, such as potassium or sodium is maintained during the coating operation. Preferably also the metal, which is to be coated, is preliminarily subjected to the action of the electropositive metal end is thus cleaned and prepared for the coating before it enters the coating bath. The operation as described is carried out in a cast-iron vessel which contains a layer of the fusible metal, resting on the bottom, and a supernatant molten electrolyte, preferably the hydroside of an alkali metal. An anode of iron dips into the electrolyte and is fixed close to the surface of the molten metal. A wire of iron, copper or other metal which it is desired to have coated, is directed by suitably placed rollers through the bath of molten caustic alkali and the fused metal, it being moved by any desirable means. The cast-iron vessel in which the molten bath is contained, constitutes the cathode of this apparatus, and the electrodeposition of the alkali metal will therefore take place both upon the surface of the molten metal and upon the wire to be coated. The alkali metal rapidly diffuses in the molten metal, and thus serves to secure a closely adherent and uniform deposit of the coating metal. That portion of the alkali metal which is deposited upon the wire effectively cleans it by reducing any coating of oxide on the surface, on account of which operation the necessity of a preliminary extensive pickling or cleaning of the wire, previous to the coating, is avoided. The path of the wire through the electrolyte may be increased, if desired, in order to insure a thorough cleaning. An alternative construction of the apparatus shows a pot with two compartments, in one of which electrolysis is carried out as above, while the wire to be coated travels through the second compartment, which communicates at the bottom with the first one, so that the molten metal can freely pass over. The wire is thus not exposed to the cleaning action of the alkali metal previous to the coating operation. A third alternative construction shows also a two-compartment vessel, in one part only of which electrolysis is conducted, while the molten metal can freely communicate with the other compartment. The wire, however, in this instance, passes through the electrolyte in one compartment, before it is being coated, and passes out in the other compartment without coming there into contact with the electrolyte again after coating. The process is not limited to the coating of wire only, nor need it be a continuous one, the essential requirement being that a due proportion of the electropositive metal be maintained in the molten metallic bath during the operation of coating.

Electroplating Tank.—J. B. Brothwell and G. F. Penley, Torrington, Conn. Patent 781,327, Jan. 31, 1905. Application filed Jan. 11, 1904.

The tank is intended specially for the plating of small articles, and the essential part of the apparatus consists of a tumbling barrel in which the articles to be plated are rolled about while the plating is going on. The rotating tumbling barrel proper is mounted upon a revolving shaft in such a manner that it can be adjusted in horizontal or more or less inclined positions, as may be required during the operation. It is counterweighted so that it can easily be brought to the desired position. A flexible conductor in the form of a chain, which is connected to the wire from the negative pole of a source of current, drags through the solution and makes contact with the articles to be plated. The tumbling barrel contains more or less liquid according to the angle at which it is tilted, and it can be quickly emptied by lowering it. The articles can therefore easily be inspected and dumped out at any time, preferably by holding a sieve under the mouth of the vessel so as to catch the plated articles, and a tight vessel under it, for catching the electrolyte. This method of plating is stated to have the advantage that the articles are tumbled and finished, and that a more durable and lasting plating is

obtained. The apparatus is also stated to have the desirable feature of exposing the articles more or less during the plating operation, which permits of their inspection, and it also does away with the laborious practice of stringing the articles on wires. The mechanical construction of the rotating parts is described in detail.

Apparatus for Nickel Plating.—J. W. Aylsworth, East Orange, N. J. Assignor to Edison Storage Battery Co. Patent 781,867, Feb. 7, 1905. Application filed Sep. 15, 1903.

The apparatus is primarily intended for carrying out the process described in Mr. Edison's patent of July 28, 1903, which was described in ELECTROCHEMICAL INDUSTRY Vol. I, p. 469, relating to the welding of a nickel film deposited on an iron or steel surface to the latter by heating the plated objects in a non-oxidizing atmosphere, for the purpose of making the articles thus treated practically homogeneous and relieving the tension existing in the plated deposit. Tension is made in the apparatus to carry out the above process in a continuous manner. Fig. 2 shows the apparatus in longitudinal cross-section, as applied to the plating and welding of a long, very thin end, finely perforated strip of steel, which is subsequently cut up into sections of the required length, and formed
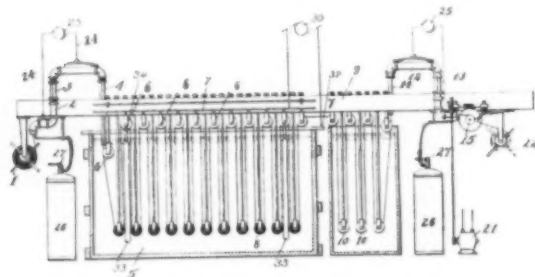

FIG. 2.—NICKEL PLATING APPARATUS.

into pocket sections for receiving the active materials in the make-up of storage batteries of the Edison type. The thin strip is carried on a reel 1, from which it passes through a tubular testing chamber 2, which has a glass section 3 for insulating the top and bottom sections of the heating chamber from each other, and also serves to observe the temperature of the heated strip. From there the strip travels through pipe 4 into the plating tank 5, which is filled with a solution of nickel ammonium sulphate. The nickel anodes, preferably in the form of rectangular bars 33, are suspended from conductors 32 along both sides of the tank, by means of hooks 34. The strip forms the cathode, the source of energy for electroplating being shown at 30. The strip passes over conducting pulleys 6 at the top, all connected to the dynamo 30 by conductor 7, and over insulating pulleys 8 at the bottom, all pulleys being supported from beam 9. The strip then passes over pulleys 10 in washing 11, which contains water. It then travels through the heating chamber 12, which corresponds to the heating chamber 2 and has also a glass section 13. The strip then passes over a feed wheel 15 of suitable construction, actuated by mechanical means driven by motor 21 and is then wound on a reel 22. The strip is heated electrically by means of conductors 24 and dynamo 25 before plating, and in the circuit formed by another dynamo 25 and conductors, after plating. A non-oxidizing atmosphere in the heating chamber 12 and a reducing atmosphere in heating chamber 2 is provided by connecting hydrogen tank 26 with them, provided with a regulating valve 27. The heating of the strip in the chamber 2, and in the presence of hydrogen, effects a reduction of any oxide on its surface, so that it enters the plating both thoroughly deoxidized and cleaned. The strip passes through the plating bath at such a rate as to receive the required thickness of coating. After being heated to a welding heat in chamber

12, it is permitted to cool until its temperature is reduced below the oxidizing point. The apparatus is, however, not only claimed for as applied to nickel plating only, but also to electrolytic plating of any other metal, the adhesion or the character of which are improved by being heated to a welding temperature. The feature of continuous cleaning and electroplating may also be used for electroplating various metals, even if the heating feature is dispensed with.

Process of Reducing Pure Copper.—L. M. Lafontaine, Paris, France. Patent 782,145, Feb. 7, 1905. Application filed Sept. 12, 1903.

The inventor prepares a bath composed of a saturated solution of sulphate of copper free from iron or other sulphates, to which has been previously added eight or ten centiliters(?) of pure sulphuric acid for each liter of the solution, any precipitate being filtered off. About one kilogram of lampblack is added to each 500 liters of the solution, it being claimed that a more regular and dense deposit is obtained by this means. A soluble anode is placed in the bath, which anode for copper ores or pyrites is formed by constructing a compartment between two perforated partitions with closed bottom and top. The compartment is made of wood and is adapted to receive from 500 to 1000 kilograms of ore. A plate of copper ½ to 1 centimeter thick, and covering a surface equal to ⅝ of the width and height of the vat as put into the center of the compartment, the ore or pyrites being packed around as compactly as possible. In the case of the treatment of mattes, the latter are prepared by casting them into plates. Concentrates or dust are agglomerated by preparing a bath of concentrated quicklime, and when the lime is slacked introducing a quantity of concentrate in the proportion of 70 per cent of concentrate to 30 per cent of quicklime, the mass being stirred so as to form a paste or mortar. The object is to enable the dust produced in the pyrites and the ores to be utilized without roasting. It is stated that concentrates thus agglomerated with lime can be transformed into sulphate of copper until they are completely exhausted, without danger of disaggregation of the agglomerated anode. The mass is then molded in rectangular molds five or six centimeters thick, and corresponding in surface to the size of the vat. The cathode is always formed of a thin plate of pure copper one-half to one millimeter thick, and having a surface corresponding to the anode. Better results are claimed to be obtained when the electrodes are connected in tension.

STORAGE BATTERIES.

Negative Pole Plate.—P. Seeliger, Hagen, Germany. Assignor to Electric Storage Battery Co., Philadelphia. Patent 781,745, Feb. 7, 1905. Application filed June 18, 1903.

If substances such as finely divided carbon, kaolin or chinaclay are added to the active material for storage battery purposes, the shrinkage of the active material during continued use may be prevented. If sufficient of the inert material be added, an expansion of the active material may take place, resulting in increase of volume. The inventor has discovered that the loose structure thus produced in the mass is especially suitable for use in connection with active material for negative pole plates. The expansion of the material may continue until the original volume has been doubled or more, and by this action the loss of capacity of the negative plates during their life is prevented. The active material thus prepared expands from the plate, gradually loses contact, and may in a short time fall off and leave the grid bare, and in order to prevent this, the spaces of the grids which contain the active material are covered by perforated retaining plates. The receptacles or spaces of the grid are only partly filled with active material, so as to leave ample room for further expansion. Fig. 3 represents alternate constructions of plates embodying this principle, showing the perforated plates *a*, the grid *b* and the active material *c*, which can grow into the empty spaces *d*. A further series of alternative constructions embodying the same prin-

ciple in its application to one plate or two plates superposed upon each other are described in the specification.

Storage Battery Electrode.—E. A. Sperry, Cleveland. Assignor to National Battery Co., Buffalo. Patent 781,795, Feb. 7, 1905. Application filed Jan. 27, 1904.

The electrode consists of a framework of vertical and horizontal bars, providing rectangular openings. The frame is
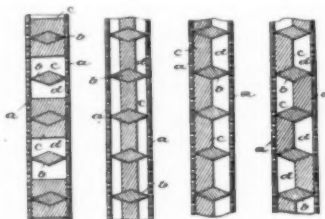

FIG. 3.—STORAGE BATTERY PLATE CONSTRUCTION.

preferably cast of antimonial lead in upper and lower half sections, which are burned together or connected by solder. Each of the rectangular openings contains a separate electrode section which is fastened to the frame at its upper edge only, thus leaving spaces all around between its side edges and the frame. Each section is wrapped over with strips of pyroxyline fabric, so as to retain the active material. The sections are retained in the frame opening by lugs which extend from the frame, and are so located that the bending of each electrode section produces a minimum deviation. The fabric cover of each section not only prevents adjacent electrodes from coming into contact, but serves as a cushion for the sections as they become expanded by use. This cushioning action is stated to be important in portable batteries as permitting the use of a lighter frame and one containing a higher percentage of antimony, and which is therefore more brittle, though it resists oxidation better.

Storage Battery.—J. Melzer, Cleveland. Patent 780,365, Jan. 17, 1905. Application filed April 2, 1904.

The invention aims at providing an apparatus which can be charged from a source of direct or alternating current. The cell is divided into two independent compartments by means of a plate of lead, which also constitutes the positive electrode. Both compartments are filled with dilute sulphuric acid. To one compartment a preferably bifurcated lead electrode is immersed, while a flat electrode of aluminium is similarly immersed into the compartment. When the cell is to be charged by direct current the aluminium electrode is cut out of the circuit and charging is effected by means of the two lead electrodes. When alternating current is used for charging, the central lead plate is disconnected, one terminal of the current being connected with the aluminium electrode in one compartment and the other with the lead electrode in the other compartment, the central plate serving as bipolar intermediary electrode during the operation.

GALVANIC ELEMENTS.

Battery.—Uri D. Foster, Meriden, Conn. Patent 781,817, Feb. 7, 1905. Application filed Sept. 30, 1904.

The invention relates especially to "medical" batteries, special means having been provided to secure the electrolyte from splashing out when the battery is carried around. For this purpose the electrodes are of special construction, with so-called "anti-splash" flanges.

MISCELLANEOUS.

Device for Preventing the Formation of Scale in Boilers.—A. Stewart, Chicago. Patent 779,326, Jan. 3, 1905. Application filed Feb. 12, 1904.

The device consists of a central tubular rod of metal on which are sitting at suitable intervals alternating discs of copper and zinc, separated from each other by metal collars. The zinc and the copper discs are stated, when thus arranged, to form the electrodes of a battery, of which the boiler water forms the electrolyte and the electric current thus generated is supposed to precipitate the calcuous matter in the boiler water and to prevent the formation of scale. The device is enclosed in a crate of wood, so as to keep it out of contact with the boiler shell.

Method of fastening abrasive material to metal bodies.—E. G. Case, Niagara Falls. Patent 779,639, Jan. 10, 1905. Application filed April 29, 1903.

The inventor aims at providing an abrasive material, the surface of which has materially increased wearing qualities and permanency. It consists in the mechanical application of an abrasive substance such as carborundum, or an equivalent material to the surface of a metal body, and at the same time subjecting the latter to an electroplating process. Thus as the abrasive material is applied to the body, a metal coating is deposited over and around its surfaces, which fixes the abrasive material permanently to the support.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

INDUSTRIAL APPLICATIONS OF ELECTROCHEMISTRY.

Electrolytic Iron.—The *Zeit. f. Elektrochemie* of January 20, contains an article by S. Maximowitsch, of the laboratory of the Russian Bank Note Engraving Bureau in St. Petersburg. The object of his experiments was to get electrolytic iron which is both solid and flexible. Since the extreme hardness and brittleness of electrolytic iron is due to an occlusion of hydrogen, a suitable electrolyte should contain the hydrogen ions in as small a concentration as possible. He found ferrous bicarbonate solutions to be such an electrolyte. The starting salt is commercial $FeSO_4$, chemical purity being not required; to get a high conductivity, he applies $MgSO_4$; in order to change a part of $FeSO_4$ into $Fe(CO_3H)_2$, he used $NaHCO_3$. The Na salts do not increase the conductivity of the solution of the bath in the same degree as NH_4 salts, but in a bath which is of very high conductivity, the distribution of the lines of current, and, hence,

the thickness of the deposit, lacks greatly in uniformity. The bath was made as follows. A vessel of six liters was filled with a solution of 20 per cent $FeSO_4 + 7aq$ and 5 per cent $MgSO_4 + 7aq$. The two electrodes had a size 20 by 15 cm., a wrought-iron plate was used as anode, while a copper plate was used as cathode. To facilitate the taking off of the iron deposit, the copper plate was slightly silver plated and iodized. After the addition of 25 grams $NaHCO_3$ a dirty froth of yellow color formed on the surface which changed after three days into a brilliant brown film. The solution which was first muggy, got gradually clearer, while a voluminous deposit was precipitated. Twice a week $NaHCO_3$ was added in quantities of 20 to 25 grams; the total quantity of the bicarbonate used in four weeks was 186 grams. This would be sufficient to change 300 grams $FeSO_4 + 7aq$, or 25 per cent of the total quantity of the iron salt into carbonate. When protected by the ferric hydrate film against the action of the

oxygen in the air, the solution remained absolutely clear, but got muggy and was decomposed by the action of air, and with great rapidity by boiling. The quantity of the dissolved $Fe(CO_2H)_2$ in a sample was 0.23 per cent. The deposit, as well as the film on the surface prevent the further decomposition of the bath, and should not be removed. The dirty color of the bath has no bad influence, but the electrodes should not reach into the sediment. Immediately after the first addition of $NaHCO_3$ the circuit was closed; to control the quality of the iron deposit, it was interrupted at intervals of two or three days. "The current density varied between 0.2 and 0.3 amperes." The first deposit was light gray and brittle. The deposit became more and more solid and flexible, until, finally, after four weeks, the bath was in its best condition. The iron deposit then obtained was specially suitable for plates for engravings. It reaches a tensile strength of 5180 kg. per sq. cm., and is at the same time so flexible that it can be bent to a sharp angle without showing a fracture. "The best current density is 0.3 amperes, maximum current density up to 0.6 amperes." The ampere-hour efficiency is 97 to 99 per cent. A bath made up as described will not give at once a flexible iron deposit; it is necessary to pass a current of moderate strength through it for a long while. It seems that a certain quantity of anodically dissolved iron in the bath is of great importance for the condition of the deposit. In one case a bath which had given good results ceased working properly after some time; the iron became brittle and full of holes. He then introduced pure carbonic acid into the bath; the result was very good, and the bath was restored nearly to its original good condition. In this way it is possible to maintain the bath for a longer time in proper working condition.

Chlorination versus Cyanidation.—The discussion started by W. E. Greenawalt's articles and noticed on pages 35 and 79 of this volume, is continued in the correspondence columns of the *Engineering and Mining Jour.* In the issue of January 12 P. Argall gives figures to show that the total cost of chlorination is much higher than that of cyanidation. In the issue of January 19 W. E. Greenawalt and J. W. Gibbs reply to a former letter of P. Argall. W. E. Greenawalt emphasizes that the possibilities of electrochlorination have not, by any means, been exhausted. He predicts that "within two years every chlorination plant, treating Cripple Creek ore, will be equipped with an electrolytic plant to generate its own chlorine; already, in at least one more of the large mills, they are preparing to generate their own chlorine by electrolysis." Concerning the small experimental chlorination plant at Colorado Springs, he (as well as J. W. Gibbs) says that "as an experimental plant, it was a qualified success, it did absolutely everything, from a technical view, that was claimed for it." The re-treatment of chlorination tailing, by cyanide, has failed wherever it has been attempted; on the other hand, the property of saving additional values, by an extra treatment, is not peculiar to cyanide. Concerning the plant in Boulder County, mentioned by Davis, in which electrochlorination was replaced by the cyanide process, it is said that this change was made after treating 75 tons of ore by a new management; "the reason why the chlorine did not extract the gold, was evidently in the roasting," since a new roasting furnace had just been installed. Although the change was made over a year ago, only 238 tons of ore were treated by cyanide; the mill was shut down soon after, and not a pound of ore has been treated since. "It is yet to be demonstrated that the changing of the process was not an unwarranted expenditure of the company's money." To Davis' criticism that Greenawalt overlooks the difference between molecular and nascent chlorine, the latter replies that "in the chlorination of ores there is no difference; a few bottle tests will show this; even if nascent chlorine had a greater affinity for gold than molec-

ular chlorine, it would have a greater affinity for the base elements also, and the sum total, in any process where the time is appreciable, would be the same." W. H. Davis replies in the issue of Feb. 9. He states that cyanidation, as practiced throughout the mining world to-day, leaves little room for improvement. No objection is raised by him to standard chlorination; "it is a time-honored process, and in some cases, no doubt, gives better results than any other process; but the same is also true of the cyanide process; conditions favorable to good extraction in either chlorination or cyanidation are much the same, namely, finely divided and free value; when these conditions are not present, neither process will extract a high percentage. Cyanidation has been applied to ores of low value for the reason that the process is less expensive to operate. But, it does not follow that cyanidation is restricted to ores of low grade; Cripple Creek ores prove this." He gives a few correcting notes on the Boulder County plant mentioned by Greenawalt. This plant was rigged, for a temporary test run, and it treated as such 238 tons; it was then decided to arrange the mill for cyanidation, but the company soon found itself in litigation, which caused the delay. This constitutes no proof of failure of the cyanide process. The writer strongly objects to Greenawalt's statement that in the chlorination of ores, there is no difference between molecular and nascent chlorine. He makes the following argument. When chlorine is set free from chloride compounds, it appears as nascent chlorine ("state A"); under normal conditions, it will combine with itself as Cl_2—if nothing more basic is present—this is "state B". This change from A to B liberates E units of energy, which is absorbed as heat by the solvent, or lost by radiation. Before this chlorine can combine with basic metals, it must again return to state A, which requires the expenditure of E energy units. This, under working conditions of a chlorination plant, must come from the reaction between the chlorine and some metal in the ore—gold or otherwise. If the basic metal has a high
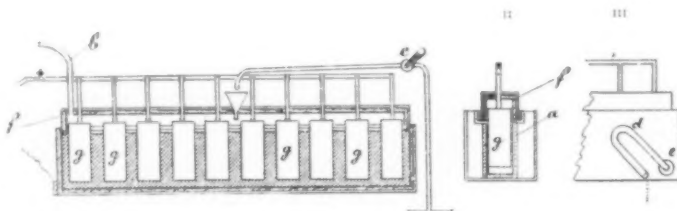
FIGS. 1, 2, 3.—DIAPHRAGM CELL.

solution pressure, like sodium or potassium, E would be readily supplied; but if the metal has a low solution pressure, like gold, E would become a commercial factor.

Diaphragm Cell for Sodium Chloride Electrolysis.—In the *Zeit. f. Elektrochemie,* January 6, L. Rostosky, in a report on his recent visit to this country, describes the McDonald cell as used in the Standard Chlorination Works in Colorado Springs, Colo. (For a previous description of this cell see our Vol. I., page 387.) The writer was struck by the great simplicity of the arrangement of the cell room. In Colorado Springs there are 75 cells in three parallel rows. Each cell (Figs. 1 to 3) consists of a cast-iron tank, 0.3 m. high and broad, and 1.57 m. long. Two longitudinal partition walls of perforated sheet steel divide each cell into three compartments; these walls are covered on their inner side with asbestos paper, lined with cement, for the sake of greater strength. After about eight months the diaphragms must be renewed, since they gradually become clogged. The middle compartment contains the anodes g (Fig. 2), there being 10 anodes in each cell. The graphite anodes (Fig. 4a) are 30 cm. long and have a cross-section of 10 by 10 cm. After ten months they look like Fig. 4b, and are then removed from the bath and reversed (Fig. 4c) and are used for three or four

more months. The cell is rendered gas-tight by slate plates *f*, 1 cm. thick. The chlorine gas passes off through the lead pipe *b*. The supply of sodium chloride solution was formerly automatic, but since this was not successful, it is now regulated by hand by means of the cock *c*. The temperature of the electrolyte is said to be 85° to 90°. The concentration of the lye, flowing out off the cathode compartment, increases from 7 per cent to 18 per cent caustic soda, and decreases to 6 per cent sodium chloride, so that finally the ratio of caustic
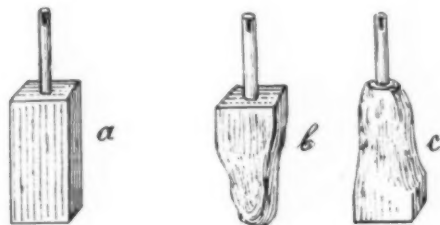

FIG. 4.—GRAPHITE ANODES.

soda to sodium chloride is 3 to 1. The caustic soda solution is removed by the bent tube *d*, which may be turned around *e*. When the diaphragm is new and perfectly permeable, this tube is adjusted to a high position, and the level in the anodic compartment is approximately equal to that in the cathodic compartment. Later on, the tube is turned gradually to a lower and lower position, so that the height of the electrolyte in the cathodic compartment is only a few centimeters, and the poorer permeability of the diaphragm is counteracted by the mechanical pressure of the anode liquid. At the same time it seems that in this way the hydroxyl ions are prevented from passing into the anode compartment.

The Electric Furnace in the Iron and Steel Industries.—The well-known Canadian Commission report is the object of some criticisms by J. O. Arnold in (Lond.) *Nature*, January 12. Concerning the experiments made with the Keller electric furnace at Livet on the reduction of pig iron from ore, it is said that "the commission saw smelted several tons of pig iron, as a rule remarkably high in managanese (1.5 per cent to 4 per cent), and hence of limited commercial interest" * * * "From a British point of view Kjellin's induction process deserves the most serious attention in view of (under certain conditions) its probable competition with the crucible steel process. Analytically, mechanically, and micrographically this steel leaves nothing to be desired, but unfortunately chemical and tensile tests, and the indications of the microscope, have a limited value in determining the working capabilities of tool steel." The author urges that evidence as to the equality of electric steel to crucible tool steel on a commercial scale "can be conclusively obtained only by at least two comparative years of shop practice, employing all kinds of tools, and recording the average wear and waste of the steels as evidenced by the ratio between the work turned out and the annual cost of the tool steels purchased." * * * "Prolonged test on Kjellin steel of all carbons, compared with similar crucible steels, have been inaugurated at the University College of Sheffield, and the erection of a Kjellin furnace capable of making one ton of steel per day is under consideration." The writer speaks of some conclusions of the commission as "hasty and ill-digested," although he "cordially" congratulates Héroult, Keller and Kjellin "on the scientific ability displayed in the development of their several methods, all of which, within their legitimate spheres, are undoubtedly of great metallurgical value."

Electric Resistance Furnace.—The January issue of *Elektrochemische Zeitschrift* contains the conclusion of the article by J. Bronn on electric smelting of glass. The author first gives some brief notes on various patents which have been

taken out in connection with this subject, and then describes in greater detail various electric resistance furnace constructions (crucible furnace, muffle furnace), which are heated by means of the granular resistance material Kryptol.

Electro Zinc Plant.—Electrogalvanizing continues to make steady progress, the process being largely used for two purposes, viz., as a protection for steel tubes for boilers during the time of assembling and erection, and also for the purpose of detecting flaws in the tubes in the early stage of construction, as it is found that the tubes, after pickling, if flashed with a thin coating of zinc, readily show any inherent flaw. One of the latest plants is described in the Lond. *Elec. Rev.*, January 6, the process being that of Cowper-Coles; it is installed at the works of the Aktiebolaget Aandviken, Finland. The plant consists of a galvanizing tank of 20 feet long, which is connected to two regenerating tanks, in which zinc dust, mixed with coke, is placed for replenishing the zinc in the electrolyte, as it is electrodeposited on the iron plates. A lead-lined centrifugal pump, driven off the dynamo shaft, is used for circulating the electrolyte. The anodes employed in the Cowper-Coles regenerating process are lead, attached to compound anode and cathode bars.

Calcium Cyanamide as Fertilizer.—In a recent address before the Farmers' Club in Berlin, a reprint of which we received from the author, Prof. Frank gives some notes on the production of calcium cyanamide and its use as fertilizer (see also page 79 of our last issue). In the manufacture on a commercial scale one electric hp.-year "fixes 250 kg. of nitrogen in form of about 20 per cent calcium cyanamide;" the watt-hour efficiency is about 33 per cent, and it is expected that it may be improved. The quantity of cyanamide required as fertilizer on one hectar (1 hectar = ca. 2½ acres), is 150 to 300 kg., corresponding to 30 to 60 kg. nitrogen. In order to avoid irritations of the workingmen by dust, the cyanamide is mixed with the double quantity of dry soil. The fertilizer is to be applied about a week or two before sowing the seed, and must be mixed with the soil 3 to 5 inches below the surface.

Production and Utilization of Ozone.—The long article by J. B. C. Kershaw is concluded in the Lond. *Elec. Rev.*, January 6. The author describes briefly the experimental plant of Siemens & Halske at Martinikenfelde, near Berlin, and the commercial plants at Wiesbaden and Paderborn for the sterilization of drinking water by ozone (see our Vol. I, p. 179). The author reaches the following conclusions. The use of ozone for water purification and sterilization has emerged from the experimental stage of its development, and under certain conditions this method of purification can be operated with successful results, both commercially and otherwise. The conditions required to make such an installation a success, however, are exceptional, and it seems unlikely that ozone, or, more correctly, ozonized air, will be employed on a very extensive scale for sterilizing the water supply of great cities. It is both cheaper and safer in such cases to go far afield for water, and to obtain a pure supply, than to take the polluted river water that happens to be near at hand, and to purify it by treatment with ozone in special purifying plants. But in small towns and villages, where the initiation of large waterworks schemes is impossible, owing to the financial outlay involved, the ozone treatment for purifying and sterilizing an impure water supply near at hand would seem to have a future field of usefulness. The Schierstein and Paderborn works are examples of such installations. Siemens & Halske estimate that a plant capable of dealing with 126,000 cubic feet of water per day could be erected for an outlay of $32,000, this cost covering all the pumping and filtering plant of the waterworks—and installations half this size would, no doubt, prove sufficiently large for many small town and village communities. The possession of an ozone sterilization plant, as a stand-by in times of severe epidemic of typhoid, enteric and similar fevers, would also be an aid to the preservation of

health in large city communities, since at such times the ozone plant could be put into use, and the water supply to the affected district of the city could be thoroughly sterilized. The purification of water by ozone would also appear to have a future in works where drinks and beverages of all kinds are manufactured for public use, and possibly also on board ships and in military camps, where the necessary supply of steam or electricity for generating the current can be obtained. While the application of ozone to water purification is unlikely, therefore, to revolutionize the present system of obtaining water for drinking and other purposes in our great cities, it will, undoubtedly help in certain cases and under certain conditions to solve the problem of a pure water supply, and as the yield of ozone is increased by improvement in the form and working of ozonizers, this field of usefulness is likely to widen and extend. Since the theoretical yield of ozone per e. h. p. hour is stated to be 1000 grams, and the maximum yet obtained is 184 grams, or an efficiency of only 18.4 per cent, there is still ample room and opportunity for improvements in ozonizers; and the progress in the ozone industry is likely to depend very largely upon the success of inventors in turning to useful work some portion of the 82 per cent of electrical energy still unaccounted for in the usual form of ozonizer tube and apparatus.

THEORETICAL AND EXPERIMENTAL.

Vanadium, Niobium, Tantalum.—In our last issue we gave a resumé of W. von Bolton's work with tantalum which has resulted in the construction of the tantalum incandescent lamp by the Siemens & Halske Co. Von Bolton now gives a summary of his researches in the *Zeit f. Elektrochemie,* January 20. When investigating the conductivity of solid electrolytes. Nernst succeeded in maintaining magnesia rods of uniform cross-section for a long time at white incandescent heat, by passing the electric current through them. Electrolysis takes place whereby the magnesium oxide is decomposed into magnesium and oxygen. But both combine immediately again to magnesium oxide. If such a Nernst lamp filament is placed in a vacuum, the oxide is strongly pulverized, the oxygen being given off and recombining with the magnesium at short intervals until the filament burns through at some place. It is the same with the other oxides which may be used in the Nernst lamp. Von Bolton found that vanadium, niobium and tantalum oxides behave in a quite different way. He first experimented with vanadium; he made small rods of the brown vanadium oxide, mixed with paraffin, and heated them, embedded in granular carbon, to a temperature of about 1700° C., whereby the paraffin evaporates, while compact rods of trioxide remain in the original shape. Rods were thus made, 20 mm. long, with a diameter of 0.8 mm., and placed in a vacuum, and while evacuation was continued, these rods were heated electrically with a current of 1.8 amperes at 42 volts; they then became white hot and gave off much gas which was collected in a separate vessel and proved to be oxygen. The rods had assumed a metallic gray color. The walls of the vacuum vessel had been darkened with a brown powder, due to the evaporation of the oxide. The reduced vanadium filaments were then brought into a new vacuum and their melting point was determined photometrically by Lummer's method. The filament melted at moderate white heat and consumed in the average 3.5 watts per candle, giving 0.42 candle per square millimeter surface, which corresponds to a melting point of vanadium at 1680° C.

Similar experiments were made with niobium. Its melting point was found by a corresponding method to be 1950° C. Finally tantalum was experimented with, which was found to be the most suitable for an incandescent lamp, since the melting point is between 2250° and 2300° C. The author first gives some historical notes on the preparation of tantalum and mentions especially the experiments of Berzelius and Rose. They produce tantalum by heating the potassium and tantalum fluoride (K_2TaF_7) with potassium, and extracting the potassium fluoride with water, but this method does not yield pure metallic tantalum, but contains only about 5 per cent of the pure metal. Moissan described in 1902 the production of tantalum in the electric furnace by reducing the oxide with carbon; but his metal contained about 0.5 per cent carbon and was therefore either a carbide (0.5 per cent C. being a pretty large quantity in view of the high, atomic weight of tantalum) or it was an alloy of the metal with carbide. Von Bolton describes briefly two methods of producing pure metallic tantalum.

The first method is electrolytic reduction of one of the oxides in the incandescent state in a vacuum. He formed filaments of brown tantalum tetroxide and placed them in a vacuum. By passing the electric current through, they were caused to glow slightly, whereby much air was driven out of the porous filaments. Evacuation was then continued and the temperature of the glowing filament was increased until, at beginning white heat, several points of the filament showed strong incandescence. These points gradually extended to longer and longer lines, until the filament was incandescent uniformally along its whole length. During this reaction much gas was given off, which was identified as pure oxygen. The brown color of the original oxide had changed into pure metallic gray, and the wire had become flexible after several hours of strongest white incandescence, like a wire of copper.

The second method, which is the more practical one, is to produce tantalum by the method of Berzelius and Rose mentioned above, and then to purify and refine the metal in the vacuum under the action of the electric arc. This method is based on the fact that the oxides of tantalum melt more easily than the tantalum itself, and on the other fact, that they are much more easily pulverized in a vacuum than the metal, so that the metal can be completely separated from the oxides.

The specific heat of tantalum is 0.0365, the atomic heat 6.64, so that the law of Dulong and Petit is valid. The specific weight is 16.5. The author gives some further numerical data on various chemical and physical properties of tantalum. The tantalum lamp has a useful life of 400 to 600 hours, during which it consumes 1.5 watts per cp. Useful life means the time at the end of which the lamp has lost 20 per cent cp. In the first hundred hours, the cp. increases whereby the specific energy consumption decreases to about 1.3 watts per cp., it then increases, and at the end of its useful life the lamp consumes 1.8 to 2 watts per cp., but the lamp continues to burn up to 1000 and 1500 hours. Since the ordinary carbon filament lamp consumes 3.5 watts per cp., the tantalum lamp consumes less than half the energy for the same useful life. The author finally gives some data on reactions between the tantalum and various elements, and on the properties of alloys of tantalum. The investigation has consumed several years and the co-operation of nine investigators is acknowledged by the author. The importance which Siemens & Halske attribute to this investigation is indicated by the fact that they have taken out or applied for about 200 patents in Germany and other countries with about 1000 claims.

Alternating Current Electrolysis.—The paper of Brochet and Petit, recently abstracted in these columns, is the subject of two articles in the *Zeit. f. Elektrochemie,* January 6, in which M. Le Blanc and R. Ruer offer various criticisms. The former promises a complete summary of his own researches for the furture, while the latter objects to the theory of Brochet and Petit, concerning the solution of platinum by alternating current, and describes some experiments to refute their theory and to conform his own proposition that the solution of platinum in sulphuric acid by alternating current in the presence of an oxidizing agent is due to the fact that "the oxidizing agent weakens the cathodic component of the alternating current and thus changes the symmetrical alternating current into a non-symmetrical one with a preponderant anodic component."

METALLURGY.

IRON AND STEEL.

Dry Air in Blast Furnaces.—A Pourcel has discussed the results of Mr. Gayley's experiment, in *Revue de Metallurgie* for January. He repeats the mistake made by Le Chatelier, in supposing that the composition of the slag was charged, made less basic, and in consequence more fusible and requiring less heat for its fusion, and thus the heat requirement of the furnace was diminished, when working with dry air. That there is no foundation for this view is evident from the fact that Mr. Gayley did not change the proportion of limestone to ore during his experiments; he did, however, use less coke with dry blast, and that would bring in less ash, and therefore diminish the total quantity of slag per ton of pig iron made, while its basicity would be increased by the absence of some coke ash. Altogether, there was a slight saving in heat requirement, due to the smaller amount of slag made per unit of pig iron. Pourcel further discusses the heat saving as produced by increasing the temperature of the crucible and decreasing that of the upper part of the furnace, but he does not give any very convincing reasons why the furnace should act that way with dry blast. He concludes that the idea of drying the blast is not likely to make progress in Europe until a less complex and less onerous method of drying it than that used by Mr. Gayley has been invented. Many metallurgists disagree with this conclusion: *Nous verrons.*

The Utilization of Blast Furnace Gases.—Charles de Mocomble has given us in *Revue de Metallurgie,* for January, a most admirable treatise, occupying sixty quarto pages, on this interesting and important subject. He devotes ten pages to the general considerations of the operation of a blast furnace, in which the waste gas is stated to vary from 18 to 36 per cent in carbonic oxide, and in calorific power between 860 and 1150 calories per cubic meter; it is also assumed that on an average the calorific power is 900 calories; that 3.5 cubic meters of blast are needed for each kilogram of fuel charged, at a temperature of 700° C., and that 4.5 cubic meters of waste gas are formed, leaving the furnace at a temperature of 150° C.

Chapter II. consists of fifteen pages devoted to the utilization of the gases to heat the blast, by means of hot-blast stoves. A table shows the content of dust in the gases to vary between 1 or 2 grams and 50 grams per cubic meter (all above 20 grams were when producing spiegeleisen), and to average about 5 grams. The gas being free from dust, it is burned to heat the stoves; and the writer calculates how much gas is needed to heat the blast used up to 800° C., assuming that the gas is used at 150° C., the theoretical amount of air is used for combustion, and that the stove has an efficiency of 95 per cent, i. e., that the stove losses only 5 per cent of its heat by radiation, conduction, leaky valves, etc. There are two mistakes in this calculation; the efficiency of stoves averages more nearly 75 per cent than 95 per cent, and the mean specific heat of air per kilogram between 15° and 800° is 0.251 instead of 0.237. The writer, in fact, finds that the actual efficiency, as shown by some tables which he has compiled from actual practice, is between 56 and 85 per cent, and he therefore disregards his own assumptions and proceeds with 60 per cent as an actual value for the heating efficiency of the stoves, which requires 0.4 cubic meter of gas to be burned in the stoves per cubic meter of blast heated to 800° C. (instead of the 0.29 cubic meter which his own assumptions and calculations led to). This would require 1.4 cubic meters of gas to heat the 3.5 cubic meters of blast needed for each kilogram of fuel burned, leaving 4.5, 1.4 or 3.1 cubic meters of gas to be otherwise used, equal to 69 per cent of the total gas produced. This figure is about right; a modern furnace uses only about 35 per cent of its gas in the hot-blast stoves, and has 65 per cent, for other purposes. Mr. de Mocomble assumes for his further discussions that practically

35.5 per cent of the gas is needed for the stoves, and 64.5 per cent is otherwise available.

In chapter III, ten pages are devoted to the use of the excess gas in boilers. A table of tests made by different observers between 1891 and 1904 shows a utilization of from 33 up to 75 per cent of the calorific power of the gas burned. The best boilers can scarcely maintain an average of 70 per cent under actual working conditions, and the type of boiler used around blast furnaces is usually so far from the best, that the writer feels compelled to assume a utilization of 45 per cent as representing average blast-furnace practice. This figure leads to the production of 0.56 kilogram of steam at 4 or 5 atmospheres pressure for every cubic meter of gas burnt under the boilers. While the best steam engines will supply one horse-power hour for 4 kilograms of steam at this pressure, the writer assumes that the average blast-furnace engine will require 10 kilograms, which leads to the necessity of burning 18 cubic meters of gas per hour for each effective horse-power produced. It is then calculated that the furnishing of the power for compressing the blast will require, per kilogram of coke burned, 1.85 cubic meters of gas (assuming that the piston displacement is double the air actually received by the furnace and that the pressure of the blast is 0.4 atmosphere, or 6 pounds per square inch). This requires 41 per cent of all the gas made by the furnace, leaving 64.5 — 41 = 23.5 per cent otherwise available. The writer has not, however, allowed for the power necessary for raising the charges, pumping water, running a pig-casting machine, lighting plant, etc. In many works these items use up all the remaining surplus.

In the fourth and last chapter, of twelve pages, the use of the 64.5 per cent surplus gas in gas engines is discussed. Tables showing results already obtained prove that from 2.5 to 5 cubic meters of gas have been used per hour for producing one horse-power; that the requirement of large engines is now not over 2.5 cubic meters, giving a mechanical efficiency of 25 per cent on the heat value of the gas used. For the purposes of his calculations, the writer assumes a consumption of 3 cubic meters per hour per indicated horse-power, and 4 cubic meters per hour per effective horse-power of the blowing engine, corresponding to a net efficiency of 17 per cent. Since the boilers and steam engine required 18 cubic meters, the gas engine is 4.5 times as effective. Since there is available 3.1 cubic meters of gas per kilo of coke burned, there is producible $3.1 \div 4 = 0.775$ horse-power for every kilo of fuel burned per hour in the furnace. Of this power, 9 per cent is required for the blowing engines (0.070 horse-power for every kilo of fuel burned per hour) leaving available for all other purposes, in round numbers, 0.7 horse-power for every kilo of fuel charged per hour. Since, in a furnace producing 100 tons of pig iron daily, there is used about 4000 kilos of fuel per hour, there is a 2800 horse-power developable by gas engines over and above the power requirements of the furnace. [The subject above noticed is one of the most rapidly-advancing branches of the metallurgy of iron, and bids fair to realize all predictions and expectations. The abstractor pointed out the possibilities in this direction by a series of calculations printed in the Journal of the Franklin Institute for December, 1900.]

On account of limitations of space, a number of abstracts had to be reserved for our next issue.

Artificial Rubies.—A recent consular report states that artificial rubies have been produced in France by "reducing small, natural rubies into a very fine powder, which is melted in an electric furnace, cooled rapidly, and crystallized. The product obtained, from what was of little worth, on account of minuteness, possesses a comparatively high value. The main difficulty encountered is to prevent cavities and fissures in the crystals. The new process cannot be employed with emeralds and sapphires, as they become discolored by the action of the heat."

RECENT METALLURGICAL PATENTS.

ROASTING FURNACES.

R. L. Lloyd and P. Thill (781,834 February 7) object to the use of a number of successive hearths in an ordinary roasting furnace, on account of the excessive quantity of flue-dust produced. They therefore provide a helical continuous hearth (Fig. 1); to effect the continuous progression of the finely divided ore, stirrer arms are arranged in each of the spaces between the turns of the helix.

The inventors provide for a rotary reciprocation of the arms and arrange for their following the pitch of the helix in their downward movement for a little more than half a revolution (if the arms are angularly displaced 90° apart). At the end of their stroke they are first raised vertically a sufficient distance to clear the body of ore on the hearth, and are then rotated backward, being depressed at the beginning of the stroke, until they again engage the ore on the hearth. To diminish the amount of power required, the inventors counterbalance the feeding devices, so that as one of the furnace-operating mechanisms is lowered the counter-weight is raised: the mechanism is supported on hydraulic cylinders.

FIG. 1.—HELICAL HEARTH OF ROASTING FURNACE.

F. Heberlein and W. Hommel (781,824, February 7) patent a horizontal rotary muffle furnace of circular construction, the principal object being to prevent the furnace gases mingling with those evolved from the ore. Immediately below the ore-chamber, the floor of which rotates, is a heating chamber which rotates with the floor, while a stationary heating chamber is provided immediately above the ore chamber. The heating gases circulate first through the lower, and then through the upper heating chambers, these chambers being divided into compartments, so as to direct the passage of the gases.

G. O. Petersson (781,904, February 7) patents a roasting furnace, shown both in longitudinal section and in cross-section in Fig. 2. It consists of a shaft a, contracted at the
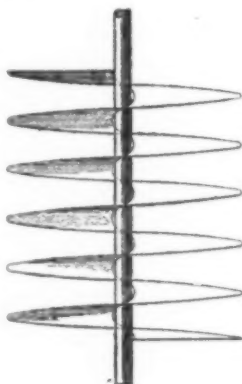

FIG. 2.—ROASTING FURNACE.

bottom and traversed by a number of arches, b, c, d. The space beneath the bottom arch at one end communicates with the outer air through passages e, arranged in one of the abutment walls of the arch, while the other end is connected with a gas-fire chamber and a chamber f, arranged beside the latter

in the other abutment-wall. The gas is supplied to the fire-chamber through a pipe g. The space beneath the arches c, situated above b, communicates at one end with f and at the other end with h, arranged in the opposite abutment-wall and communicating at its upper part with one end of the space beneath the arches d. This space at the other end communicates with chamber i, which connects with the chimney k. The air used for the combustion of the gas will thus be heated by the material to be roasted in the lower part of the furnace as the air passes to the chamber f, and the products of combustion subsequently flow back and forth through the material to be roasted on their way to the chimney.

COPPER.

Certain native copper-bearing rock carries the copper so finely divided that processes of mechanical concentrations are unsuitable. F. R. Carpenter (781,807, February 7) claims that such ores may be cheaply treated by a smelting process, if a carrier or collector for the copper is used. He therefore adds some sulphide material, such as iron, pyrite, pyrrhotite, etc., which collects the finely disseminated native copper. Clean slags are made with the use of limestone. The copper conglomerate, pyrite and limestone are charged with sufficient coke into a blast-furnace; there is formed a very light slag and a very high-grade matte, the former free from copper and the latter containing the copper in form of sulphide, since the copper which was originally free has united with the sulphur, displacing the iron.

VANADIUM.

There exists in many localities ores of vanadium, mainly sandstones, having the general composition 0.5 to 5 per cent vanadium, 74 per cent silica, alumina, etc. Notwithstanding the high temperature required for the reduction of vanadium compounds and the readiness with which it reoxidizes when reduced, F. R. Carpenter (781,808, February 7) claims that such ore "may be smelted even in an ordinary blast furnace, provided the fuel and blast are arranged so as to produce a high temperature and a strong reducing action, and a carrying metal is present with which the vanadium may alloy." As such a carrying metal, iron may be used, which is introduced into the charge in the form of iron oxide. In order to slag off the large amount of silica present in the ore, a basic flux, as dolomite, is added. The vanadium is obtained in form of ferro-vanadium, usually containing also silicon.

ALLOYS.

T. Prescott (781,300, January 31) patents an alloy of a light and strong character, suitable for pattern-plates or patterns for foundry work, machine-bearings, etc. It consists of 53.50 to 74.75 parts of zinc, 25 to 43.5 parts of aluminium, 0.25 to 2 of iron, 0.25 to 1 of silicon.

L. H. E. Lacroix (782,401, February 14) patents an alloy intended to serve as a substitute for lead for most of the purposes for which the latter is used, while it has the advantages of greater strength for the same thickness. "Thus, for instance, if the new alloy is used for roofing in place of lead, the beams and other parts of the structure can be made lighter. The alloy is more easy to treat than lead and can be rolled into exceedingly thin sheets and drawn into very fine wire." The alloy consists of 1000 parts lead, 15 antimony, 1 sodium.

ZINC.

C. E. Dewey (781,133, January 31) patents the following process of treating zinc-sulphide ores containing iron. The ore is first roasted in such a manner that the zinc is converted into zinc sulphate and zinc oxide and the iron present converted into ferric oxide as far as practicable. The roasted ore is charged into a V-shaped tank with water, and is there held in suspension by the introduction, at the bottom of the tank,
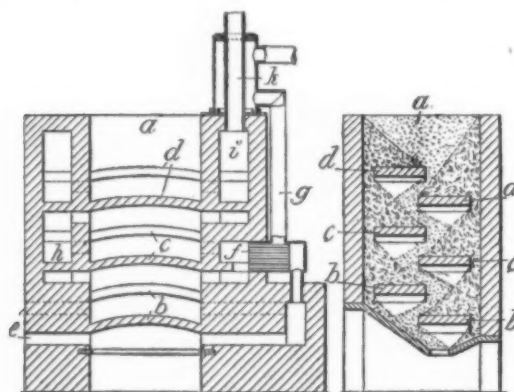
of a mixture of air and sulphurous gas from the roasting furnace; or a mixture of steam, air and sulphurous gas may be introduced. Thereby "the zinc oxide present is dissolved and converted into zinc sulphite, and through a reaction with the ferric oxide present in the ores, the zinc sulphite is converted into zinc sulphate, in which form the zinc is removed from the residue of the ore by filtering, decantation, or in any other suitable manner." The ore is then washed in order to remove the balance of the zinc sulphate, and enough of the latter is removed with the wash-water to form the latter into a weak solution of zinc sulphate, and the subsequent charge of roasted ore is introduced into this weak sulphate solution instead of pure water, as in the case of the first charge.

CYANIDE PROCESS.

A. H. Brown (781,711, February 7) proposes to reverse the order of operation in ordinary cyanide practice, by beginning with cyanidation and following this up by concentration. He objects to the ordinary practice for the reason that in case of most gold and silver-bearing ores the use of water in crushing by stamps or rolls or in connection with the concentrating process occasions much loss of values due to sliming, since the recovery of the values from the slimes requires an extensive system of settling tanks beyond the limits of ordinary plants. In Brown's process it is first subjected to the action of a cyanide solution whereby the finer values are dissolved, and second to concentration whereby the coarser values are recovered. The whole operation may be briefly described as consisting of the following five steps: (1) pulverization of the ore in the presence of cyanide solution; (2) hydraulic classification by the introduction of cyanide solution at the bottom of an overflow-tank to produce an ascending current; (3) leaching the ore by the use of cyanide whereby the finer values of the ore are dissolved; (4) precipitation of the dissolved metallic values from the solution; (5) treatment of the residue of ore by concentration.

BARREL-FILTER.

H. C. Holthoff (782,031, February 7) patents a barrel with a barrel arranged centrally or co-axially, so that the balance
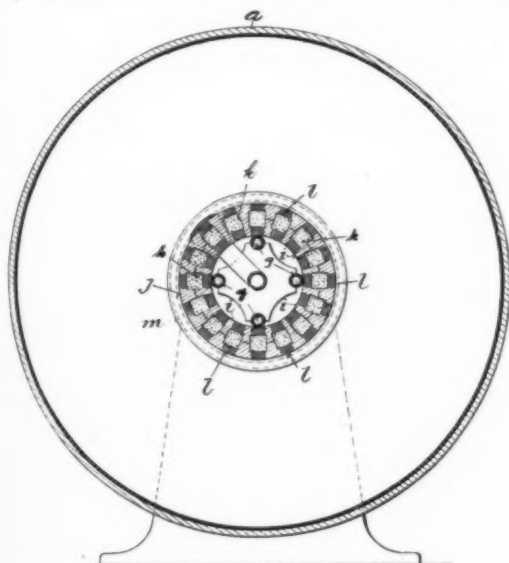

FIG. 3.—FILTER.

of the barrel is maintained and less power is required to rotate it. Fig. 3 is a cross-section; a is the barrel, in the center of which is arranged the cylindrical filter frames of lead or porcelain, which is composed of inner or outer shells i and j,

having in the outer side of the inner shell and in the inner side of the outer shell, cavities which coincide with each other and from cells k, the opposite outer and inner walls of which are perforated with small holes l. The component shells of the filter frame are made in segmental sections, bound together and held in place upon the lead-covered rods g by steel or iron rings m, encased in lead. The cavities or cells k are filled with coarse sand, crushed silicious stone or other suitable granular material.

On account of limitations of space, notes on a number of patents which were granted during the past month had to be reserved for our next issue.

BOOK REVIEWS.

TECHNO-CHEMICAL ANALYSIS. By Dr. G. Lunge; authorized translation by Alfred I. Cohn. 12mo., viii. + 136 pages, 16 figures; cloth, $1.00. New York: John Wiley & Sons, 1905.

This compact and yet comprehensive little book is written by a past-master in technical chemistry, and contains information and advice of value to anyone having to determine the quality of raw materials or products of chemical processes, or to control the steps of a chemical manufacture. The scope is best disclosed by an enumeration of the principal headings: Technical Gas-Analysis, Gas-Volumetry, Fuels and Heating, Examination of Water, Sulphurous and Sulphuric Acids, Nitric and Hydrochloric Acids, Salt, Soda, Sulphate Cake, Carbonates and Bi-Carbonates, The Chlorine Industry, Potassium Salts, Clay and Cement, Artificial Fertilizers, Gas and Ammonia Manufacture, Calcium Carbide, Coal-Tar Industry, Mineral Oils, Oils and Fats, Soaps, Glycerine, Sugar, Alcohol, Vinegar, Wine, Beer, Tanning and Dyeing.

Within the scope of the subjects named and the limits of size of the book, the matter is most satisfactorily handled. The information is not elementary, yet very clearly presented. The work can be satisfactorily used by any one who knows the rudiments of chemical manipulation, and at the same time will be found useful by the expert analyst.

NOTES ON ASSAYING AND METALLURGICAL LABORATORY EXPERIMENTS. By Richard W. Lodge: 8vo., viii. + 287 pages, illustrated; cloth, $3.00. New York: John Wiley & Sons, 1904.

Nearly two-thirds of this work is a very clear and superior treatise on assaying. Complete explanations are given concerning the assay for silver, gold, lead, bullion, copper, tin and the platinum metals. The methods used by the author in the Massachusetts Institute of Technology are described first, and are followed by other reliable methods. The method of presentation is entirely up to date, and contains all those little touches which evidence that the work is perfectly familiar to the author, and he puts it in such manner as to make it easy to the reader or student.

The latter third of the work describes the metallurgical laboratory test, made by fourth-year students in the author's laboratory. The processes chosen are Plattner's chlorination process, the cyanide process, bromination and milling of gold ores, retorting amalgam, chloridizing of silver ores and pan amalgamation. The directions given are complete, with almost German-like attention to detail, and form a very helpful guide in the restricted part of metallurgical laboratory work which they cover. The book, as a whole, is particularly a work for students, and gold and silver metallurgists.

KALENDER FUER ELECTROCHEMIKER, SOWIE TECHNISCHE CHEMIKER UND PHYSIKER. 1905. By Dr. A. Neuburger. Berlin: M. Krayn. Price, 4 marks.

The Kalender appears this year in its ninth edition. The book undoubtedly contains a great deal of useful information in a concise form. During the last years it has been the

editor's aim to constantly improve the contents, and the book bears evidence of this at many places. That among the mass of miscellaneous data thus collected, there should be more or less inaccuracies is not surprising. One part of the book, which is evidently in need of revision and of being brought up to date, is that dealing with technical electrolysis and electrothermics. The price for electric energy, for instance, at Niagara Falls, is given as 3.2 centimes per kw.-hour for a consumption of at least 80,000 kw.-hours per month. This, for 8760 kw.-hours or a kw.-year figures out at $56, a price far above that actually charged. The surprising statement is also made that the Conley process is carried out in this country "on a large scale," and that "pig iron, cast iron and steel are manufactured by it directly" from the ore. The chapter should be revised by a practical iron metallurgist, as far as the electrometallurgy of iron and steel is concerned, so as to avoid statements as the following., which is translated literally: "One can manufacture in one and the same apparatus, at the same time, all possible kinds of cast iron, iron, and steel," and others of the same character.

THE POLISHING AND PLATING OF METALS.—By Herbert J. Hawkins. Chicago: Hazlitt & Walker. Price, $2.00.

The author of this new book on electroplating modestly states that he is not seeking to enlighten the skilled men of the profession or to air his own opinions, but to help the younger element of the trade. The book is a typical trade publication, and is of value in giving the experience of a practical plater conversant with modern shop practice. A commendable feature is the omission of historical matter and the large number of impractical formulæ for solutions which usually burden books on electroplating.

Mr. Hawkins does not pretend to treat the subject from the scientific standpoint, and for justification says that "the science of electroplating is so new and changing so rapidly that writers on the subject are comparatively few, and those we have are generally students rather than practical men." That the book is not scientific, the reader must agree. It is admitted by the author that "a general knowledge of chemistry pertaining to plating should be very beneficial to the practical plater and a thorough knowledge of dynamos and electricity should also be of value," but he says that such knowledge is easily "obtainable at small cost in this age of night schools and correspondence schools."

The first one of the seventeen chapters points out defects of previous works, discusses different kinds of platers and states the author's views as to a practical manual. The second chapter presents "some points on hygiene for platers" and from the author's personal experience with boils, sores and other afflictions arising from cyanide and "potassium poisoning" a warning is given against drinking from vessels which have contained cyanide solutions and unnecessary dipping of the hands in such plating baths. We are also told that there is no valid ground for the belief that a plater should be a user of tobacco or alcohol. In spite of the dangers that lurk about the profession of plating he finds it most attractive, comparing his love for it with a sailor's love for the sea, and concluding with the opinion that "once a plater, always a plater."

Those parts of the book which deal with the polishing room, its machinery and management, acid dips and pickles, their composition and use, the arrangement and management of the plating room and methods of setting up and operating gold, silver, nickel, copper and brass plating solutions, is thoroughly practical and should prove of value to the student of electrochemistry, as well as to apprentices in the plating business. It is noticeable, however, that Mr. Hawkins pays but scant attention to the use of the sand-blast for the treatment of work preparatory to plating, though this process is being extensively employed for cleaning, as well as for finishing metal surfaces.

The chapters dealing with the construction and management of dynamos and electrical measuring instruments should be revised to free them from various misstatements. Some of the author's views relative to the laws of electricity and magnetism are startling revelations to the "student," however helpful they may be to the "practical man." The ampere is defined as that quantity of current which will pass through one ohm in one second at one volt pressure. Following a somewhat vague description of ampere-meters and voltmeters it is claimed that "the ampere-meter is simply an extremely sensitive mili-voltmeter with a different scale." Mr. Hawkins states that "there is much more to the subject of voltmeters and ampere-meters" than he gives, but he surely should have made reference to the shunt which makes it possible for an extremely sensitive milli-voltmeter to indicate hundreds of amperes.

The discussion of the effects of current density on the character of metal deposit concludes with a table on page 175, giving the current densities required to plate different metals upon thin sheets. For thick sheets or heavy work which *can conduct heat rapidly*, it is said that the current densities given may be multiplied by from six to ten. The explanation for this, which is given on page 172, includes a statement that a dynamo bought to do work according to tables of suitable current densities, will be wholly inadequate for anything but thin sheet metal. "It is easy to see," says Mr. Hawkins, "how this mistake arose. The limit of quantity of current is at that point at which the *metal commences to discolor from the heat evolved* when the metal is deposited out of the solution; a thin plate conducts heat slowly beyond a given quantity. On the other hand, a large heavy piece contains metal enough to conduct heat away as fast as it is formed, and ten or twelve times as much current may be used profitably on such work." The author has apparently applied a too literal meaning to the designation "burned coating," which electroplaters give to a bad deposit.

Again, on page 175 is a statement implying a contradiction of Faraday's laws, where it is claimed that "in computing the surface of work in the tank all surface which the solution touches must be counted, whether it plates or not, as current will pass through it even if it does not plate." It is difficult for the student to understand why a current density of ten amperes per square foot flowing to the interior surface of a hollow object will not deposit a coating, while it does so on the outside. Statements such as these can scarcely be considered as tributes to the intelligence of practical platers, and can only lead to confusion on the part of the apprentice.

While the author may, perhaps, have been justified in offering an empirical rather than a scientific treatise on electroplating, he should have used greater care in his treatment of scientific principles where he found it necessary to deal with them.

A Colorado Concentrating Plant.

One of the most modern and efficient concentrating plants in this country—interesting alike in the compactness of the general design and in the extensive use of a novel screening device—is the new mill of the Green Mountain Mining & Milling Co., of Silverton, Colorado. The plant was designed by the Traylor Engineering Co., of New York City.

The mill handles an ore concentrating from 3 to 5 tons into one, the ore carrying gold, silver, lead and copper. In the design of the plant the aim was to make such arrangements as to classify the ore product before and after crushing, to have the feed to each machine under perfect control, as well as being automatic and capable of being operated with the least possible number of men. The plant is a double unit, coarse and fine concentrating mill, each unit of which can be operated entirely independently of the other. Fig. 1 gives the plan and Fig. 2 an end section of the mill, while

A Storage bin
B Gyratory Crusher
C Crusher Elevator
D Single Unit Dry Centripact Screen
E Oversize Bin
F Plunger Feeders
G Blake Crusher
H Sampler
I Belt Conveyor
J Mill Storage Bins
K Single Unit Dry Centripact Screen
L 36" x 16" Improved Standard Rolls
M Elevator to Single Unit Screens
N Elevator to Triple Unit Screens
O Triple Unit Wet Centripact Screens
P 4-m. Jigs
Q 14-m. Jigs
R 20-m. Jigs
S Unwatering Screens
T Unwatering Tanks
U Chilian Mills
V Sand Pumps
W Single Unit Wet Centripact Screens
X Wilfley Concentrators for Screen Oversize
Y Settling Tanks

a Wilfley Concentrators for Settling Tanks
b Slime Tanks
c Wilfley Concentrators for Slime Tank Product
d Draining Table
e Concentrates Settling Tank
f Shoveling Platform
g Wet Concentrates Elevator
h Revolving Dryer
i Dry Concentrates Elevator
j Dry Concentrates Sampler
k Dry Concentrates Bins
l Dry Concentrates Chutes
m Dry Concentrates Dust Settling Flue
n Slime Launders
o Centrifugal Pumps
p Tailing Launder
q Tailing Sampler

Note Parts of Unit No. 1 indicated thus '
" " " " No. 2 " " " "

FIGS. 1 AND 2.—PLAN AND END SECTION OF CONCENTRATING PLANT.

Fig. 3 is a flow-sheet which will enable the reader to follow readily the travel of the ore from the storage bin at the head of the mill to the concentrating tables. The course of the ore through the mill is in detail as follows:

The ore is drawn from the storage bin, under control, to a No. 4 gyratory crusher. From the crusher the ore goes to an elevator and is conveyed to one single unit 1-inch mesh dry Centripact screen, the construction of which will be described below. The oversize from this screen passes down into a 50-ton storage bin, feeding back a Blake crusher through an automatic plunger feeder. From the crusher the ore is delivered to the same elevator and is returned to the same screen for further classification.

All product passing through the 1-inch meshes of the screen goes through an automatic sampler which at regular intervals takes portions of the product, thus enabling the mill

FIG. 3.—FLOW-SHEET.

management to determine at all times the assay value of the ore passing through the mill. After the sample has been taken, the remainder of the product is delivered upon a 16-inch conveyor belt located over bins, as shown in both plan and section, Fig. 1 and 2. All product in these bins, which serve as the general mill storage bins, is thus 1-inch and finer.

From this point on, the plant is in duplicate, and one unit only need be described. From the storage bins, the ore is fed through an automatic feeder to a single-unit dry Centripact screen of 3-mesh. The oversize from this screen goes by gravity to a set of heavy-duty roughing rolls, and the product fine enough to pass through is delivered directly to the boot of the general mill elevator leading to the triple-unit Centripact screens, water being meanwhile added. These screens, located above the jig floor, are in duplicate, thus insuring continuous operation.

The product passing through the rolls is delivered to the

boot of a second elevator which re-elevates it back to the same single-unite Centripact screen for further classification, and so on. Thus, all product delivered to the triple-unit screens is 3-mesh or finer. The screens on the triple-unit Centripact are respectively of 6-mesh, 16-mesh and 25-mesh. The oversize from the first of these screens is delivered to two 2-compartment jigs fitted with sieves of 4-mesh. The undersize from the first screen is delivered to the second screen, the oversize from which passes to two 2-compartment jigs fitted with sieves of 14-mesh. The undersize from the second screen passes on to the third screen, the oversize from which is delivered to two 2-compartment jigs fitted with sieves of 20-mesh. The product passing through the third screen, all of it being 25-mesh and finer, is delivered to one or another of three 50-mesh, single-unit wet screens.

All jig tailings are conducted in a launder to an unwatering screen located over an unwatering tank, thus separating and controlling the surplus water and preventing the passage of this surplus water through the Chilian mill. The product passing through the unwatering screen settles to the bottom of the tank and is drawn through a draw-off gate with such water as required and enters the Chilian mill simultaneously with the oversize from the unwatering screen. The surplus of overflow water from this tank, carrying more or less value in fines, is delivered directly to a general slime tank. In the

FIG. 4.—DOUBLE-UNIT CENTRIPACT SCREEN FOR DRY WORK.

Chilian mill, the jig tailings are recrushed down to 30-mesh, the mill discharging toward the rolls to a Frenier pump by which the product is elevated to the three single-unit wet Centripact screens referred to above. Thus, the Chilian mill product is mixed with the undersize from the third screen of the triple-unit set above referred to. The three single-unit screens are equipped with brass wire cloth of 50-mesh, as already noted. The oversize, which contains no slime whatever, is delivered directly to four Wilfley concentrating tables. The undersize, 50-mesh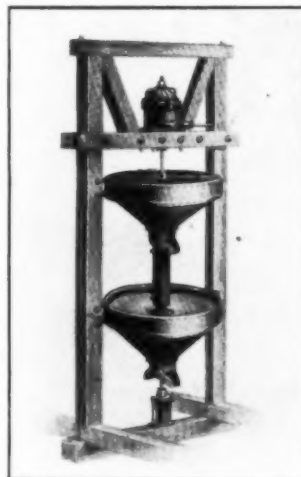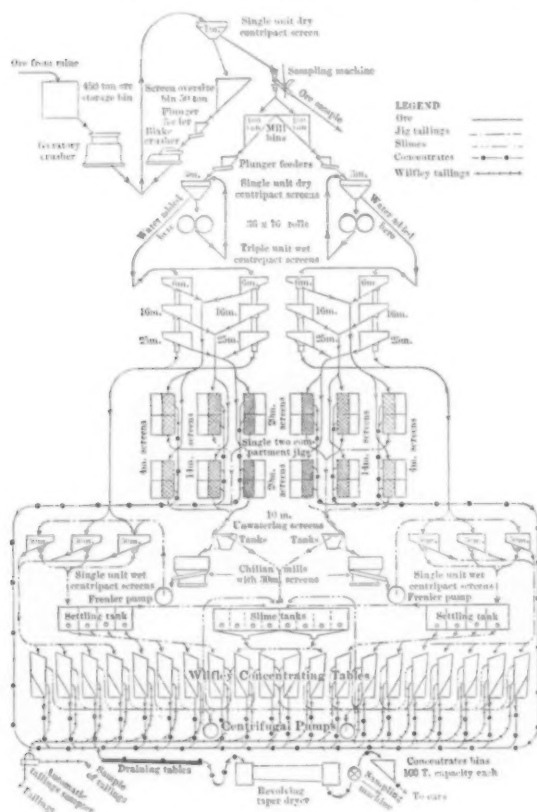 and finer, is delivered to unwatering and settling tanks from which all of the settled product, including such slimes as may be associated with same, is delivered to an entirely separate set of tables. The overflow from these tanks is delivered to the general slime tanks.

On the side of each table a portable sliding launder is provided, permitting of cutting out any portion of the tailings, preferably the water crossing directly at the head of the table carrying the fine slime products. This slime product is re-elevated by centrifugal pumps to the general slime tanks where all of the surplus water, including the slimes from the general tables, are settled and drawn on to separate Wilfley slime tables for further concentration. All jig and table concentrates are drawn by gravity to drainage tables and stored for drainage before being delivered to dryer. After allowing all concentrates to drain for twelve hours, more or less, they are fed into a cylindrical dryer, and from this dryer elevated to an automatic sampler where accurate samples are taken. The concentrates are finally stored in bins whence they may be drawn automatically into railroad cars. A study of the plan, Fig. 2, will show the symmetrical arrangement of all machinery included in this plant. The separate unit shafts

which permit the driving of either unit separately should also be noted, as well as the fact that all machinery is so located that there are no belts, pulleys, or shafts in the way to prevent perfect access throughout the mill.

The chief interest in details of construction rests in the extensive use of the Centripact screen, invented by Mr. S. W. Traylor, head of the Traylor Engineering Co. This screen promises to inaugurate a very important new development in screening practice, meeting every requirement of a perfect sizer. The advantages claimed for the screen are briefly as follows:

The Traylor Centripact screen screens any material, either wet or dry, up to 100-mesh. It screens wet without any added water. It screens more accurately than does even the hand screen. The meshes of the screen are kept from clogging by its normal motion—no pounding from the outside. It is easily and cheaply installed, requires little power, and runs practically without attention. The life of the screen proper is prolonged indefinitely by the method of distributing the material over the same.

The screen proper is approximately saucer-shaped and is mounted on a vertical shaft which rotates at a speed of about 30 revolutions per minute. To the shaft and screen are also given successive vertical impacts of a frequency of about 600 per minute. The particles on the screen are thus subjected to two forces—centrifugal force, tending to drive them toward the periphery of the screen, and an upward impact, tending to make them leap from its surface. From this combination of centrifugal and impact movements—which is the fundamental feature of the Centripact screen—the name is derived.

The material is fed in from above through a launder to a feed plate at the center of the screen. From there it is distributed uniformly over the screen. Since the vertical im-
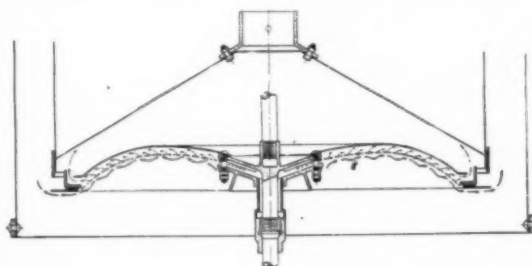

FIG. 5.—SECTION OF CENTRIPACT SCREEN UNIT FOR WET WORK.

pacts on the particles are the same over the whole surface, while the centrifugal force is the greater the further the particles are away from the center, it is evident that in order to get uniform distribution over the screen the screen-surface should not be a plane. The screen curves downward from the center and the natural movement of the material by gravity thus aids here the centrifugal force in distribution. The downward curvature gradually diminishes and the screen flattens out and finally rises in such degree near its periphery as to effectually counteract the greater centrifugal force. The material travels over the screen cloth by leaps and bounds so that wear by attrition is practically nil.

In the construction of the driving head and the arrangement of the various parts therein, the leading idea was to make the construction as simple and strong as possible.

The Centripact screen is made by the Traylor Manufacturing & Construction Co., of Newark, N. J., the Traylor Engineering Co., of New York City, being the sole representatives. The screen is built in two distinct patterns, for wet screening and for dry screening, respectively. Fig. 4 shows a double-unit Centripact screen for dry work complete. The most noticeable difference between the wet and dry screen-

ing types is in the construction of the housings, a difference made necessary by the fact that a far greater slope is required to secure a free movement of dry ore than is required for pulp. The most essential variation in the two patterns, is that, for wet screening, a sheet steel pan, conforming in shape to the screen, is supported beneath the screen cloth about three-quarters of an inch from the same, as shown in Fig. 5. The water passing through the screen is caught in the pan and flows outward over it. Owing to the action of centrifugal force, the surface of the water assumes a form corresponding to that of the screen and pan. There is thus a layer of water immediately under the screen and, with each impact, the water is projected upward against the screen, serving to clear the meshes and at the same time thoroughly irrigate the material being screened, rendering it of the proper consistency for efficient sizing by the screen.

In cases where the pulp is of a nature to corrode a screen of iron wire, screen cloth of brass or copper wire is used. When necessary, all of the parts of the Centripact which come into contact with the pulp can be protected by a wood lining or by copper sheathing.

It will be seen that in contradistinction to the hydraulic classifier which classifies according to settling power, the Centripact screen, without adding any water to the pulp, classifies it by size and by size alone.

Wood Distillation.

The old charcoal process in which the wood was charred in heaps or in kilns and all products of distillation were allowed to go to waste, is still carried on to some little extent in remote places in this country. However, in the last thirty or forty years—especially since Dr. H. M. Pierce began his pioneer work in 1876—this industry has been completely revolutionized and the recovery of the by-products—wood alcohol, acetic acid, acetate of lime—is now of utmost importance.

Mr. F. H. Meyer, of Hannover-Hainholz, a German manufacturer of apparatus for wood distillation, represented in this country by Messrs. Frederick Bertuch & Co., of New York City, has recently issued an interesting pamphlet in which he gives a full review of the modern methods of wood distillation. He distinguishes between those processes mainly used in Europe and in this country and pays attention to the different results obtained with different kinds of wood. He emphasizes that in present practice, the whole process consists of a great number of steps, with repeated evaporations, thus necessitating a comparatively high consumption of heat, work and a great many apparatus.

Mr. Meyer then gives a thermochemical review of the whole process, stating the amount of heat in calories which become available during the different operations. The result is most interesting, since it shows that in present practice more calories are available at the end of the process than are required for the treatment of the crude wood alcohol. These calories should, of course, not be wasted, and Mr. Meyer proposes to utilize the sources of heat which become available during operation for the treatment itself.

While the details of his process are not given, the gist of it is that by utilizing the "latent heat" of the wood alcohol and tar vapors escaping from the retorts, with the aid of special apparatus inserted between retorts and condensers, he obtains directly from the charring process (i. e., without a second distillation) a wood alcohol, free from tar (and turpentine), which, when neutralized with lime, and evaporated, gives directly a gray acetate of lime of great purity. The result is a saving of heat and apparatus, as well as a reduction of wages. If the process works as well on a large scale as is hoped by the author, it will be another example of a reduction of cost of operation, based on an analysis of the operation on the basis of thermochemical calculation. The author recom-

mends the more extended use of the large retorts generally employed in this country, though he apparently favors changes in construction and details.

The author states that since the publication of this pamphlet, a large-sized plant has been erected and operated in Germany, the results obtained fully justifying the efficiency of his process.

Motor-Generator Sets in Electroplating and Electrochemical Works.

By C. G. Backus.

There has been many great changes in transmission of power during the last few years. These changes have been an improvement on the old order of things, and most of these improvements have been called forth by a continual demand for increased efficiency, better regulation and economy. To attain one or all these results, all lines of manufacturers are now building their machinery to be self-contained and independent.

The factories of a generation ago, with their endless lines of main shafts, pulleys and flying belts are being replaced by modern machinery direct-connected to individual motors, which receive their power from a central dynamo or power plant by means of a system of invisible wires, instead of the cumbersome and unsightly, and often more dangerous and expensive shafting and belt system.

The various electroplating, electrotyping and electrochemical processes all require a low voltage generator, to obtain the best results with a minimum expense of power, and this style of dynamo presents such difficulties that it has only been built successfully by a few manufacturers. The Zucker and Levett & Loeb Co., of New York, one of the oldest manufacturers of supplies for electroplating and polishing material in the country has made, for years, the low-voltage dynamo the subject of careful study and development. At various times in the last thirty years they have brought out new types of generators of this class, each successive type being an improvement on its predecessor. They have long recognized the tendency of the age, and have been building for a number of years generators, self-contained and direct-connected to a motor, in sizes ranging from 25 amperes to 6000 amperes. A direct-connected motor-generator set of this type is the
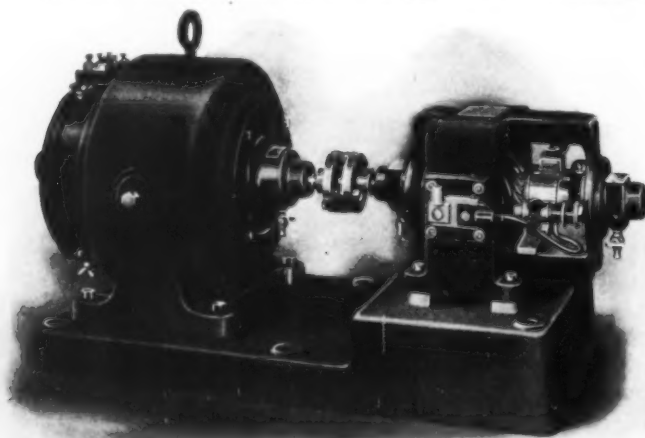
MOTOR-GENERATOR SET.

only practical direct-current transformer for low voltage work.

With the belt-driven generator it was not possible to vary the voltage, or rather to cut it down, without cutting down the field strength, or by throwing resistance into the main circuit of the dynamo. The first way destroys or impairs the bal-

ance between field and armature, thus impairing the efficiency of the machine. The second plan was a waste of energy, the power generated being absorbed and given off as heat. With the direct-connected motor-driven generator it is different. The loss of power from the tight belts is eliminated. With a speed controller for the motor, the voltage of the generator can be varied fully 40 per cent, without calling into use the two older methods above mentioned, i. e., changing the field strength or inverting resistance.

The ideal regulation is obtained by having the fields of the generator separately excited from a high-voltage circuit, as by this method, in addition to the regulation above referred to, a certain further variation can be obtained by weakening or strengthening the field by means of a field rheostat operating on a line not controlled by the speed of the generator itself; and for generators of 500 amperes or more the generator can be arranged to use the three-wire system, by which two or three different voltages can be obtained from the machine at the same time.

Armored Stoneware Cocks and Spigots

It has often been emphasized by the most successful chemical and electrochemical engineers that they experienced their greatest troubles in the solution of the numerous small problems in details of mechanical construction. A process may work extremely well in its experimental stage, but when its
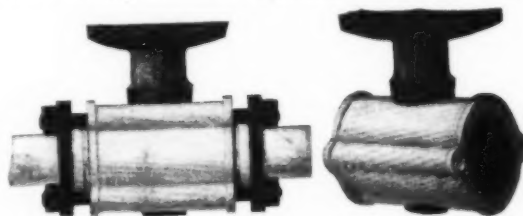
ARMORED STONEWARE BOCK.

operation is started on a large scale, innumerable troubles are experienced from such little things as leaking and wearing out of cocks and spigots. The accompanying illustration shows an interesting and novel construction of armored stoneware cocks and spigots, made by the firm of Karl Ruppel in Hoechst-am-Main, Germany, in conjunction with the German Stoneware Factory, of Friedrichsfeld, Baden, this latter concern being represented in this country by F. Bertuch & Co., New York.

Lead cocks are often liable to wear out quickly, while cocks of pure earthenware are difficult to construct for a high pressure. The construction shown in the illustration combines earthenware and lead construction, and is of extreme compactness and of great strength. It may be used with very high pressures instead of expensive hard-lead valves. The cock itself is made of stoneware armored with lead, the flanges of the connecting pipe being joined to the cock, by means of iron screws. By a special process, a homogeneous union is attained between the earthenware and the lead. The earthenware is important on account of its resistivity against chemical influences, while the lead with the screw construction yields the necessary strength. The installation is most simple; by working the screws on one side, both ends are simultaneously and uniformly tightened. The right-hand illustration shows the stone lining inside the lead armor, without the iron screws put in; while the left-hand illustration shows the cock complete, attached to lead pipe.

Industrial Notes.

Messrs. HAMMACHER, DELIUS & Co., of New York, are the American representatives of the Swedish company which makes, at Gysinge, steels of crucible steel quality in the electric induction furnace of Kjellin, which was repeatedly described in our columns.

We have received from Messrs. ELMER AND AMEND, of New York, a nicely illustrated pamphlet on electric laboratory furnaces and heating appliances in general, in which the new granulated resistance material Kryptol is used. This material is filled into the heating apparatus or spread out on clay or enamel plates; depending on the thickness of the layer of Kryptol, and on the current employed, the temperature can be regulated as desired, so that it is possible to produce at will different temperatures at various points of the heating apparatus. The great ease of handling this granular material—which will not burn through like a metallic heating wire, and which is not attacked by acid vapors—renders it applicable to a great many purposes in the laboratory without any difficulty. Among the Kryptol heating apparatus mentioned in the pamphlet are baths for heating evaporating dishes, flasks, beakers, etc.; hot plates, drying ovens, muffle furnaces, crucible furnaces and tube furnaces.

The NATIONAL BATTERY Co., of Buffalo, N. Y., has issued a fully-illustrated pamphlet on automobile batteries. The plates are of the pasted type, the positive grid being of the "staggered" form, while the negative grid is known "as the much litigated and successfully defended (National) patent form of corrugated, punched and clinched type of grid, which, having the material on two sides of the plate, welded together, firmly holds the active material to the grid and gives a large conducting area of metallic lead, the great advantage being light weight and stiffness, combined with great capacity per pound."

The BUFFALO DENTAL MFG. Co., of Buffalo, N. Y., has issued a fully illustrated catalogue of 56 pages on Laboratory Appliances for colleges, schools, chemists, assayers, manufacturing jewelers, etc. (Catalogue B, list No. 33.) The first part of the catalogue deals with various types of laboratory furnaces: gas furnaces, requiring blast; gasoline gas furnaces; kerosene blast furnaces; gas furnaces, without blast, etc. Then follow descriptions of various types of blow pipes, burners, and laboratory appliances in general.

The bauxite brick, mentioned on page 43, of our January issue, are made by the LACLEDE FIRE BRICK MFG. Co., of St. Louis. This company has just installed in its plant a complete laboratory, which is in charge of Mr. A. J. Aubrey. The company, in manufacturing fire brick, cupola blocks, tiles, sewer and culvert pipe, etc., analyzes all the raw materials entering into the manufacture. Knowing the proportion of all the different elements in the materials used, they are in position to guarantee the serviceability of its products.

CROCKER-WHEELER ANNUAL CONVENTION.—The annual convention of officers and branch managers of Crocker-Wheeler Co., took place at the main office and works, Ampere, N. J. January 26, 27 and 28. Managers and representatives were in attendance from all parts of the country, and were unanimous in predicting a prosperous season during the coming year in the field of alternating-current generators and direct-current generators and motors. On the evening of the 27th a banquet was held at the Cafe Martin in New York, at which the president of the company, Dr. Schuyler Skaats Wheeler, presided.

NEW SMELTER IN MEXICO.—It is reported that a large new smelter at the important mining camp of the Velardeña Mining and Smelting Co. (now regarded as a branch of the American Smelting and Refining Company), located between the Mexican International and Mexican Central roads in the State of Durango, will be speedily built. Its capacity will be 1000 tons, and perhaps more; it will be equipped in the most modern style for copper matte, as well as silver-lead smelting. The old smelter of the company will be abandoned when the new one is completed. It will be a custom smelter.

STEAM TURBINE PLANT IN KLONDIKE.—The Westinghouse companies have just entered an order for the equipment of a power house for the electrical operation of gold-dredging boats on the Alaskan rivers. The plan is an entirely new one and involves many interesting features. There will be installed a 400-kw. turbo-generator in the power house, to be driven by a 600-hp. Westinghouse-Parsons steam turbine. The dredge boats are being built by the Marion Steam Shovel Company, of Marion, Ohio. On these boats will be installed induction motors, aggregating a total of about 500 hp., and varying in size from 7½ to 100 hp. The fact that a plant of this nature is to be installed in such a distant country, far from the manufactory and possible repairs, shows the confidence engineers place in this type of unit. The power house will be located at Dawson City, and the dredges will operate on the Yukon River and its tributaries. Lines for transmitting power will be strung from the station to the boats, wherever they may be working.

Personal.

Dr. RUDOLPH GAHL, formerly of the Electric Storage Battery Company, of Philadelphia, has associated himself with the Denver Laboratories, assayers, analysts and electrochemists at Denver, Colo. The members of the firm are Messrs. R. Gahl, H. C. Parmelee and C. H. Bryan. Dr. Gahl, who is well known to the electrochemical fraternity through excellent and extended research work in storage battery engineering, will devote himself especially to consulting work in connection with storage battery and electrochemical engineering in general, since electrochemical methods are now attracting considerable attention in the metallurgical works of Colorado.

Mr. ANDREW CARNEGIE has taken up literary work again, and is writing a life of James Watt, of whose work he has long made an extended and enthusiastic study. The book is nearly ready.

Dr. GEORGE W. MAYNARD, who recently returned from Arizona to New York, is now leaving again to examine mining properties in Durango, Mexico.

Mr. CHARLES W. CROSS, formerly of the Roberts & Abbott Co., of Cleveland, Ohio, and later electrical engineer for the Eastern Ohio Traction Co., has entered the employ of the Crocker-Wheeler Co., of Ampere, N. J., and is attached to their Cleveland office.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

MOLTEN ELECTROLYTES, MISCELLANEOUS.

(Concluded from page 88.)

689,286, December 17, 1901, Guillaume De Chalmot, Leaksville, N. C.

Natural phosphates are mixed with a small proportion of silica sand and fused in an electric arc furnace. A certain proportion of anhydrous phosphoric acid is volatilized and absorbed by moist lime or phosphate rock in trays. The phosphate in the furnace is permitted to overflow as fast as melted, in order to avoid too great reduction of its phosphoric acid content. The molten product drops onto water-cooled iron drums together with sand to prevent adhesion to the iron, thence into water, and is crushed and utilized as a fertilizer. The material in the trays, as well as the product from the furnace, contains a large proportion of available phosphoric acid. The operation is not dependent on any electrolytic effect, and alternating currents are preferred in order to avoid reduction of the phosphate.

Electric Smelting and Reduction Processes.

319,795. June 9, 1885. Eugene H. Cowles and Alfred H. Cowles, Cleveland, Ohio.

Smelts ores, as of zinc, aluminium, silicon, magnesium and boron, by the heat generated by the passage of electricity through a body of granular material of high resistance, such as carbon or silicon. The ore, for example, aluminium hydroxide, alum, sodium chloride, calcium oxide or strontium sulphate, is usually mixed with the granular resistance material, which is contained in an air-tight chamber or non-oxidizing atmosphere to prevent oxidation. The carbon reduces the ore, but is otherwise unconsumed. Two forms of zinc furnaces are illustrated. The first is a horizontal tube of silica, embedded in powdered charcoal or mineral wool. The rear end of the tube is closed by a carbon-plate anode; the front end by a graphite-crucible cathode which opens outwardly, but is closed by a clay plug. One and one-half parts of zinc ore are mixed with one part of carbon, and the tube is filled nearly full of the mixture. When the current is passed, the zinc distills and passes through an opening in the bottom of the crucible-cathode, wherein it is condensed. The waste gases escape through a vent pipe. The second furnace is a horizontal chamber having a hearth which slopes downward from both ends to a tap-hole at the middle. The ends are closed by carbon-plate electrodes, one of which has an opening receiving the neck of a condenser. A series of hoppers open into the chamber at the top, enabling the resistance of the charge to be regulated by the amount of material fed in. Reduced non-volatile metals remain in the furnace, filling the interstices between the carbon. For the production of pure metals, pure carbon must be used.

324,658. August 18, 1885. E. H. and A. H. Cowles, Cleveland, Ohio.

Produces alloys, aluminium, silicon and boron bronzes, etc., by adding to the resistance charge described in the previous patent, an alloying metal or ore thereof. For the production of aluminium bronze, corundum, cryolite, or clay is pulverized and mixed with broken carbon and a pulverized copper ore, e. g., the oxide. The mixture is placed in a horizontal column between carbon electrodes. Copper may be substituted for its ore, rods of copper being transversely inserted into the charge, or granulated copper being mixed with it. May also produce alloys, carbides, silicides, borides and saturate aluminium with copper and iron or silicon and manganese, by the use of a Siemens electric-arc furnace. For this purpose, the alloying metal or its ore are either mixed with the charge of the arc furnace or crucible, or an electrode of the alloying metal, e. g., copper, tin, nickel or iron is used, the electrode being gradually melted and the alloying metal incorporated with the reduced metal.

324,659. August 18, 1885. E. H. Cowles, C. F. Mabery and Alfred H. Cowles, Cleveland, Ohio.

Produces pure aluminium and other metals and metalloids, such as silicon and boron, by reducing a mixture of the ore, granular carbon and an alloying metal, and then separating the alloying metal, leaving the residue aluminium in the form of an amorphous powder which is melted into an ingot. The smelting is performed by passing a current through the charge, serving as a resistance conductor, as in 319,795. The alloying metal, e. g., tin, silver copper, manganese zinc or copper prevents absorption of carbon by the aluminium. The tin, silver or copper may be removed from the alloy by amalgamation with mercury, which does not dissolve the aluminium, the action being quickened by the use of sodium amalgam, acid, electricity or heat. Manganese, zinc or copper may be removed by lixiviation. The alloy may be broken into small pieces and leached with dilute nitric acid, and the solution may be quickened by other acids, heat or electricity.

335,058. January 26, 1886. A. H. Cowles, Cleveland, Ohio.

Maintains a uniform resistance in Cowles' incandescent furnaces by employing carbon-rod electrodes which are adjustable in openings at the ends of the furnace, and are gradually drawn apart as the specific resistance of the charge decreases during the run. An electrically-controlled mechanism may be used for adjusting the electrodes, that shown being a magnet in a shunt circuit, having a vibrating armature and clock work which operates a pinion engaging a rack attached to the electrode. The connectors consist of copper boxes filled with copper shot surrounding the electrodes. The furnace walls are of firebrick lined with pulverized charcoal. The charge normally consists of pulverized carbon and ore. In starting, the electrodes are placed near together, and are gradually drawn apart as the resistance falls. The charge is covered by granular charcoal, and the furnace is closed by a slab of fireclay with vent holes. The reduced metal is found in the interstices between the particles of carbon and on the charcoal floor of the furnace.

335,499. February 2, 1886. C. S. Bradley, Yonkers, and F. B. Crocker, New York.

Reduces sodium or potassium by heating a charge of the carbonate, charcoal and chalk, in a hollow cylinder of wrought iron, heated by passing a current through it. The cylinder is set in brickwork, at a slight inclination from the horizontal, spaces in the brickwork around the cylinder being filled with asbestos or mineral wool. The terminals are rings of copper surrounding the ends of the iron cylinder. The cylinder is closed at each end with covers having inspection holes closed by screw plugs. The door at the lower end has a pipe which delivers the sodium or potassium vapor to a condenser. Fresh material is charged into the cylinder at the upper end, and the residue is taken out from the lower end. For the reduction of zinc, a mixture of zinc oxide and carbon is heated in a resistance-cylinder of carbon, preferably the mixture of graphite and clay used for crucibles. Instead of a cylinder, the reduction chamber may be built up of plates of iron or graphite-clay bricks. For the production of aluminium chloride, a mixture of alumina and carbon made up into balls is charged into a vertical resistance-cylinder of graphite and clay. The cylinder is electrically heated, and chlorine is introduced at the bottom, the chloride distilling and being delivered through a pipe at the upper end. Instead of using a resistance-cylinder, a conductor may be placed in the bottom of the chamber only, or in the sides, or in the top, in which case the materials are heated by radiation from above. The resistance may be heated by a direct or alternating current.

403,752. May 21, 1889. John C. Hobbs, Lockport, New York.

Lines furnaces of the Cowles type with sawdust, surrounding the resistance charge. The heat from the charge carbonizes the wood. The resistance of the carbon lining is ordinarily increased, to prevent shunting of the current, by soaking it in lime water.

417,943. December 24, 1889. James B. Readman, Edinburgh, Scotland.

Reduces phosphorus by electrically heating the charge, acting as a resistance conductor. The charge is made by evaporating a solution of phosphoric acid or acid calcium phosphate, incorporating the residue with carbon and desiccating; or bone-ash, or alkaline, earthy, aluminious or metallic phosphates, or metallic phosphides may be mixed with carbon. Silica or silicious aluminates, basic or acid fluxes may be added. The charge is placed in a rectangular furnace closed at the top by a fire-clay slab. At one end of the chamber is an inclined passage for the introduction of materials, having a hopper with two valves. At the opposite side is an outlet for leading the phosphorus vapor to a condenser. Downwardly inclined carbon electrodes pass through the other two sides, and the current passing between them and through the charge heats it to incandescence. Each electrode consists of a set of carbon rods held in a cast-iron head which slides in a two-part casing.